L-3/T-2/CHE **Date : 02/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

B. Sc. Engineering Examinations 2021-2022

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

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. **Question No. 1 Compulsory.** Answer any **TWO** from the rest. **Symbols have their usual meaning.**

1. (a) This question is compulsory.
"Both silica gel and molecular sieves (zeolites) are used as desiccating materials in the pharmaceutical industry. However, in gas processing plants silica gel is generally used as a solid desiccant for the dehydration of natural gas" – why? Explain with the help of the adsorption properties of silica gel and zeolites. **(15)**

(b) Due to their good adsorption properties, zeolites are frequently used in the member for dehydration of solvents. Hitachi Zosen Corporation has commercialized a membrane shown in the figure for Question no 1(b) for a hybrid distillation system that is suitable for the dehydration on ethanol. The Hitz zeolite membrane consists of a thin layer of zeolite coated onto a porous alumina tube. The membrane can produce 99.7 wt% ethanol from 91 wt% ethanol-water mixtures. **(10+5+5=20)**

(i) Find the selectivity of the Hitz zeolite membrane in the figure for ethanol/water separation.

(ii) What is the mechanism of ethanol/water vapor separation in the membrane? Explain your answer.

(iii) What will happen if the distillation column in the figure is removed and feed is directly sent to the membrane?

2. (a) Waste water from a chemical plant contains 10 mg/L of chlorophenol and is to be treated by carbon adsorbent inside two mixed tanks as shown in figure for Question no 2(a) The wastewater discharged at a rate of 3.78×10^5 L/day. Calculate the total amount of adsorbent needed every day. Given C_1 = 6 mg/L and C_2= 1 mg/L and **(18)**

$$\text{Freundlich isoherm } \underset{mg/gC}{q} = 6.74\times \underset{mg/L}{C}^{0.41}$$

(b) A fixed bed of adsorbent is used to remove organics from the air. The mass transfer coefficient of the adsorbent is $K_c = 25\ s^{-1}$, Estimate the minimum length of the adsorbent (i.e. for irreversible adsorption) to attain 99 percent removal of organics from the air. Given, the superficial velocity of air is 15 m/min and the porosity of the fixed bed is 0.4. **(17)**

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3. Warm water at 40°C is to be cooled to 30°C by counter current contact with air in a tower packed with wood slats. The inlet air has a dry bulb temperature of 31°C and a wet bulb temperature of 22°C. The mass flow rate of water is 6000 kg water/m^2-h and that of air is 3500 kg dry air/m^2-h. The individual gas phase mass transfer coefficient is $k_y a$ = 6000 kg/m^3-h-wt fraction. Determine the height of packing required for the operation. Given, the humidity ratio = 0.0145 kg water/kg of dry air. Data is given at table for Q. 3. **(35)**

4. (a) Mass transfer methods can be used as alternative techniques for heat transfer investigations- justify this statement with the help of the analogy between heat and mass transfer. **(11)**

   (b) In dialysis waste products from our blood flow through the membrane and into the dialysate. Explain the basic principles that make dialysis work. **(11)**

   (c) A company supplied samples of granular activated carbon for removing dye from wastewater. You are asked to evaluate the performance of the sample. Which experiment(s) would you perform and why? **(13)**

SECTION – B

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

Assume reasonable values for any missing data/parameters.

5. (a) We wish to absorb ammonia into water at 20°C. At this temperature, H = 2.7 atm/mole fraction. Pressure is 1.1 atm and inlet gas is 0.013 mole frac NH_3, and inlet water is pure water. In a countercurrent system we wish to operate at L/G = 15 $(L/G)_{min}$, and y_{out} = 0.00004 is desired. If H_{OG} = 0.75 ft at V/A_c = 5.7 lbmol air/(h-ft^2), determine the height of packing required. Draw a sketch of the equilibrium and operating lines. **(20)**

   (b) For a system in which component "A" is transferring from the liquid to the gas phase, the equilibrium is given by $\mathbf{y_A^*}$=0.75 $\mathbf{x_A}$.
   The liquid contains 90 mol%/of (A) and gas contain 45 mol% of "A". The individual gas film mass transfer coefficient at this point is 0.02716 kmol/m^2.s, and 70% of the overall resistance to mass transfer is known to be encountered in the gas film. Determine: **(15)**

   (i) The molar flux of A

   (ii) The interfacial concentration of A

   (iii) The overall mass transfer coefficient for liquid and gas phases.

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6. (a) A theory which incorporation some of the principles of both the **two-film theory** and the **penetration theory** has been proposed by Toor and Marchello (1958) and is called the **film-penetration theory**.

The whole of the resistance to transfer is regarded as lying within a laminar film at the interface, as in the two-film theory, but in this theory, the mass transfer is regarded as an unsteady state process. It is assumed that fresh surface is formed at intervals from fluid brought from the bulk of the fluid to the interface as in the penetration theory. However, the resistance is confined to the finite film, and material which traverses the film is immediately completely mixed with the bulk of the fluid. For short times of exposure, when none of the diffusing material has reached the far side of the layer, the process is identical to that in the penetration theory. For prolonged periods of exposure when a steady concentration gradient has developed, conditions are similar to those considered in the two-film theory.

The expression for flux is:

$$N_A = -\frac{D_{AB}}{L}\left(1+2\sum_{n=1}^{n=\infty} e^{-\left(n^2\pi^2 Dt/L^2\right)}\right)(C_L - C_A)$$

For each of these theories: (i) film theory, (ii) penetration theory and (iii) film-penetration theory, do the following. **(15)**

- State at least two assumptions and set up the differential equations
- State the boundary conditions
- Draw the concentration profiles of a component, near an interface
- Write the correlation between diffusion coefficient and mass transfer coefficient

(b) Estimate the diffusion coefficient of hydrogen in nitrogen at 25°C and 1.5 stm. Use Chapman Enskog theory (given below) and compare with experimental value of 0.38 cm^2/sec and comment on the applicability of this theory at elevated pressures. **(20)**

$$D_{AB} = \frac{0.001858T^{3/2}\left[\frac{1}{M_A}+\frac{1}{M_B}\right]^{1/2}}{P\sigma_{AB}^2\Omega_D}$$

7. (a) Define the terms Light Key, Heavy Key, Light Non-Key, Heavy Non-Key, and Feed quality. **(5)**

(b) Estimate the number of ideal stages needed in the butane-pentane splitter defined by the compositions given in the table below. The column will operate at a pressure of column will operate at a pressure of 8.3 bar. The feed is at its boiling point. The temperature at the top and bottom are 65°C and 120°C respectively. As the temperature is varied in the column, the relative volatility of the components is also varied. So, it is convenient to use the average relative volatility of the components to your calculation.

Contd.........P/4

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

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

$$\text{where,}\quad \Psi=\frac{R-R_m}{R+1}$$

(30)

N= Actual Number of stages

n_m= Minimum Number of stages

R=Actual Reflux Ratio

R_m=Minimum Reflux Ratio

8. (a) The pressure in a pipeline that transports helium gas at a rate of 7 lb_m/s is maintained at 14.5 psia by venting helium to the atmosphere through a 0.4-inch-internal-diameter tube that extends 30 ft into the air as shown in figure for Question No. 8. The diffusion coefficient of helium in air (or air in helium) at normal atmospheric conditions is D_{AB} = 7.75 $\times 10^{-4}$. Assuming both the helium and the atmospheric air to be at 80°F, determine (*i*) the mass flow rate of air that infiltrates into the pipeline. State your assumptions ***before*** you start the analysis. **(15)**

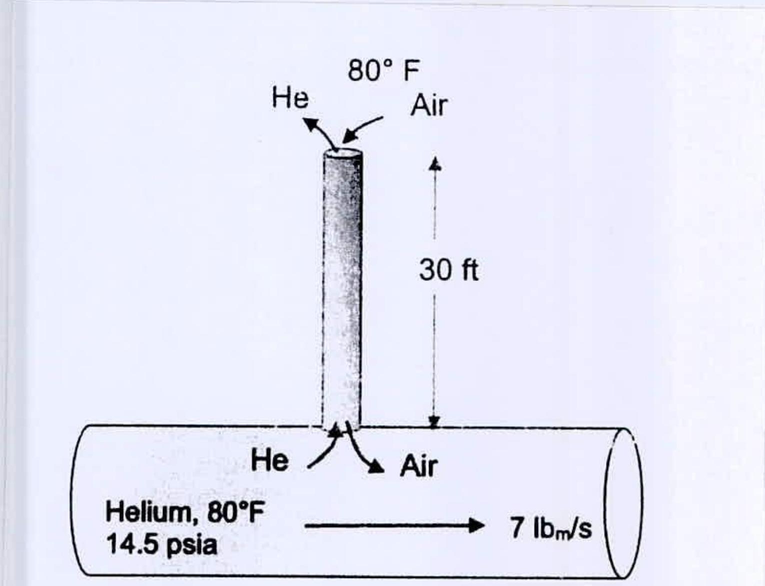

Figure 8(a)

(b) Describe in detail the steps for determination of the following

- Length of packing height
- Area and diameter of a packed column for distillation for separation of n-hexane from n-heptane using 1-inch ceramic Intalox saddles.

The parameters provided are:

Allowable pressure drop per unit height, average column pressure, bottoms and distillate concentrations, feed concentration, feed temperature, feed saturation state, L/V ratio, and flow rates of feed F, bottoms B, vapor, V and liquid, L,

Mention any other properties or parameters you may require. **(20)**

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Figure for Q no 1 b)

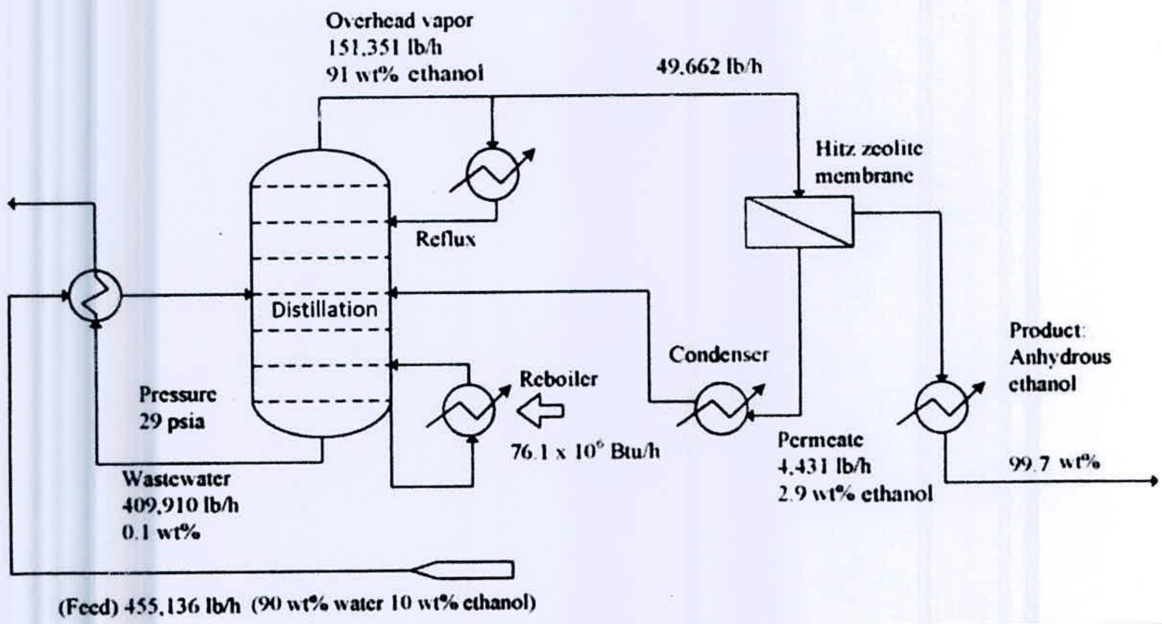

Figure for Q no 2 a)

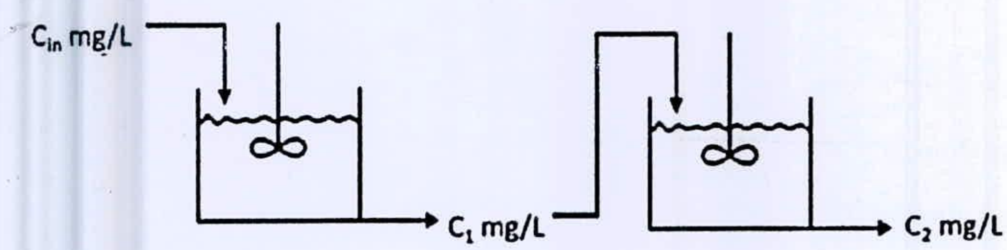

Table for Q no 3:
Enthalpy of saturated air-water vapor mixtures
(0°C base temperature)

T_L°C	H_y (kJ/kg)
15.6	43.68
26.7	84
29.4	97.2
32.2	112.1
35	128.9
37.8	148.2
40.6	172.1
43.3	197.2
46.1	224.5
60	461.5

Table : Lennard Jones parameters

Substance		σ(Å)	ε_{12}/k_B(K)
Ar	Argon	3.542	93.3
He	Helium	2.551	10.2
Kr	Krypton	3.655	178.9
Ne	Neon	2.820	32.8
Xe	Xenon	4.047	231.0
Air	Air	3.711	78.6
Br_2	Bromine	4.296	507.9
CCl_4	Carbon tetrachloride	5.947	322.7
$CHCl_3$	Chloroform	5.389	340.2
CH_2Cl_2	Methylene chloride	4.898	356.3
CH_3Cl	Methyl chloride	4.182	350.0
CH_3OH	Methanol	3.626	481.8
CH_4	Methane	3.758	148.6
CO	Carbon monoxide	3.690	91.7
CO_2	Carbon dioxide	3.941	195.2
CS_2	Carbon disulfide	4.483	467.0
C_2H_2	Acetylene	4.033	231.8
C_2H_4	Ethylene	4.163	224.7
C_2H_6	Ethane	4.443	215.7
C_2H_5Cl	Ethyl chloride	4.898	300.0
C_2H_5OH	Ethanol	4.530	362.6
CH_3OCH_3	Methyl ether	4.307	395.0
CH_2CHCH_3	Propylene	4.678	298.9
C_3H_8	Propane	5.118	237.1
n-C_3H_7OH	n-Propyl alcohol	4.549	576.7
CH_3COCH_3	Acetone	4.600	560.2
n-C_4H_{10}	n-Butane	4.687	531.4
iso-C_4H_{10}	Isobutane	5.278	330.1
n-C_5H_{12}	n-Pentane	5.784	341.1
C_6H_6	Benzene	5.349	412.3
C_6H_{12}	Cyclohexane	6.182	297.1
n-C_6H_{14}	n-Hexane	5.949	399.3
Cl_2	Chlorine	4.217	316.0
HBr	Hydrogen bromide	3.353	449.0
HCN	Hydrogen cyanide	3.630	569.1
HCl	Hydrogen chloride	3.339	344.7
HF	Hydrogen fluoride	3.148	330.0
HI	Hydrogen iodide	4.211	288.7
H_2	Hydrogen	2.827	59.7
H_2O	Water	2.641	809.1
H_2S	Hydrogen sulfide	3.623	301.1
Hg	Mercury	2.969	750.0
NH_3	Ammonia	2.900	558.3
NO	Nitric oxide	3.492	116.7
N_2	Nitrogen	3.798	71.4
N_2O	Nitrous oxide	3.828	232.4
O_2	Oxygen	3.467	106.7
SO_2	Sulfur dioxide	4.112	335.4

Table: Collision Integral

k_BT/ε_{12}	Ω	k_BT/ε_{12}	Ω	k_BT/ε_{12}	Ω
0.30	2.662	1.65	1.153	4.0	0.8836
0.40	2.318	1.75	1.128	4.2	0.8740
0.50	2.066	1.85	1.105	4.4	0.8652
0.60	1.877	1.95	1.084	4.6	0.8568
0.70	1.729	2.1	1.057	4.8	0.8492
0.80	1.612	2.3	1.026	5.0	0.8422
0.90	1.517	2.5	0.9996	7	0.7896
1.00	1.439	2.7	0.9770	9	0.7556
1.10	1.375	2.9	0.9576	20	0.6640
1.30	1.273	3.3	0.9256	60	0.5596
1.50	1.198	3.7	0.8998	100	0.5130
1.60	1.167	3.9	0.8888	300	0.4360

L-3/T-2/CHE **Date : 18/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2021-2022

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**.

1. (a) Using the corrected form of Carman Kozeny equation given below: **(15)**

$$\frac{(-\Delta p)}{L} = 150\frac{(1-\varepsilon)^2}{\varepsilon^3}\frac{\mu u_0}{D_p^2}$$

derive the expression for specific cake resistance for filtration, α in terms of particle properties only, showing in detail the material balance of the cake involved. What is unit of α? ***Be sure to define the terms you use for the derivation.***

What is the similar expression for specific cake resistance, r, whose dimensions are L^{-2}? Which expression is more accurate and why?

(b) A solute that forms cubic crystals is to be precipitated at a rate of 80,000 Ib per hour using 1,000 Ib/hr of seed crystals. According to calculations, the value of **ΔL is 0.015 inch.** Copy and complete the table (add as many columns as required) to display the product size distribution in terms of screen-size units **(20)**

Assume no nucleation occurs and the seed crystals have the following size distribution.

Tyler Sieve Mesh	Weight fraction retained (seed crystals			
-48+65	0.1			
-65+100	0.2			
-100+150	0.5			
-150+200	0.15			
-200+270	0.05			

2. Answer the following questions briefly **(35)**

(a) Write two expressions for specific cake resistance, α, suitable for compressible cakes and discuss the limitations of each expression.

(b) The graphs of size-distribution relations in an MSMPR crystallizer are shown in the **Figure for Q. No. 2(b).** Discuss the physical significance of each of the graphs, and also why the normalized values were used rather than absolute value.

(c) We can derive the expression for "population density at L $\rightarrow$ 0" from the following definition of population density at any characteristic length, L

$$n = \left(\frac{1}{V}\right)\frac{dN}{dL}$$

Contd P/2

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Contd … Q. No. 2(c)

Justify why V can be eliminated from the final derivation. Use this expression to prove

$$B^0 = Gn^0$$

(d) Discuss briefly any two practical applications of the situation where the fluid-phase flow rate exceeds the terminal settling velocity of the particles in a fluidized bed. Discuss flow regimes, where applicable.

(e) For a bed of particles, with N particles per volume of bed and sphericity of ψ and equivalent diameter = d, find the expression for a = surface area (of particle per unit volume)

3. (a) A continuous rotary filter has length equal to its diameter and is submerged 20% in a slurry. For the industrial filtration of a suspension the throughput needs to be 0.002 m^3/s of filtrate. A sample of the same slurry was tested on a small laboratory filter of area 0.023 m^2 to which it was fed by means of a slurry pump to give filtrate at a constant rate of 0.0125 m^3/s. The pressure difference across the test filter increased from 14 kN/m^2 after 300 s filtration to 28 KN/m^2 after 900s, at which time the cake thickness had reached 38 mm. What are suitable dimensions for the rotary filter, assuming that the rotary filter operates at 1 rev/min and that the vacuum system is capable of maintaining a constant pressure difference of 70 kN/m^2 across the filter? **(25)**

(b) Which filtration equipment or filtration accessory is suitable for the following situations (briefly mention your reasoning) **(10)**

(i) Quick-draining solids

(ii) Low floor space, requiring high throughput

(iii) Filter cake solids have a tendency to block the pores of the media

(iv) Wash water gets blocked during washing cycle

4. (a) A packed bed of solid hemispheric particles with diameter of 1 mm of density 2500 kg/m^3 occupies a depth of 1 meter in a cylindrical vessel of cross-sectional area 0.04 m^2. A liquid of density 800 kg/m^3 and viscosity 0.002 Pa.s flows upwards through the bed. The fluid volumetric flow rate is 0.25 m^3/hour. Calculate the mass flow rate, G, and calculate the "modified Reynold's number for packed beds". Mark on the graph, the value of modified friction factor. Use this value to determine the pressure drop across the bed. **Attach the graph with your answer script.** **(28)**

(b) At point of minimum fluidization, the bed of particles described in **part (a)** shows a fluid velocity of 0.004 m/s and the bed height is 1.8 times the packed bed height. Use a mathematical correlation to determine what type of fluidization is occurring here. **(7)**

Contd ……… P/3

SECTION – B

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

5. (a) Answer the following questions from the perspective of thickener design **(3+3+5+4)**

   (i) Define critical settling point

   (ii) Explain the concept of rate-limiting layer

   (iii) Describe the design stages for thickener using solid flux concept

   (iv) How can you handle if the thickener is operated beyond solid handling capacity

   (b) Wastewater from a de-inking plant is to be clarified by continuous sedimentation. Feed to the thickener is one million gal/day containing 1.20 percent by weight solids. The underflow from the unit analyzes 8 percent solids. Specify the depth and diameter of the thickener. **(20)**

   A single batch-settling test on the feed material gave the following information specific gravity of solids = 2.00

   Specific gravity of solution = 1.00

   Concentration of solids in test = 0.12 percent

Time (min)	Height of liquid-solid interface (cm)
0	31
5	21
10	10
20	3.2
40	2.2
60	2.1
180	2.0
240	1.96
∞	1.94

6. (a) Describe comparative differences between three types of solid-bowl centrifuges **(5)**

   (b) A tubular bowl centrifuge is to be used to separate water from a fish oil. This centrifuge has a bowl 4 inch in diameter by 30 inch long and rotates at 15,000 rpm. The fish oil has a density of 0.94 g/cm^3 and a viscosity of 50 centipoises at 25°C. The radii of the inner and outer overflow dams are 1.246 inch and 1.250 inch, respectively. **(20)**

   (i) Determine the location of the liquid-liquid interface within the centrifuge

   (ii) Determine the critical diameter of droplets of oil suspended in water and of droplets of water suspended in oil if the feed rate is 300 gal/hr of a suspension containing 20 wt% fish oil. Given that, 1 cubic feet equals to 7.48 US liquid gallon.

   (c) Derive the relationship between radial velocity and terminal velocity for designing cyclone separator **(10)**

Contd P/4

7. (a) Is it possible to apply the terminal settling velocity equation, initially developed for rigid shapes, to assess the motion of liquid droplets and gas bubbles? Provide a concise explanation. **(3)**

(b) Square mica plates $\frac{1}{32}$ inch thick and 1 inch^2 in area are falling randomly through oil with density of 55 lb/ft^3 and with viscosity of 15 centipoises. The specific gravity of the mica is 3.0. What will be the settling velocity? **(18)**

Empirical equations for calculating Drag coefficient

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

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

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

(c) A hood ornament for a new car is essentially a circle about 0.06 m in diameter. Estimate the power needed to overcome the drag of this ornament when the car is traveling at a speed of 25 m/s. Air temperature is 293K. **(14)**

8. (a) The equations giving the number distribution curve for a powdered material are $dn/dd = d$ for the size range 0-10 μm and $dn/dd = 10{,}0000/d^4$ for the size range 10-100 μm where d is in μm. Sketch the surface and mass distribution curves and calculate the surface mean diameter for the powder. Explain briefly how the data required for the construction of these curves may be obtained experimentally. **(17)**

(b) Explain the following terms in context of bin design: Tunnel flow, Interlocking, Arching and Arch breaker. **(8)**

(c) What do you understand by Mohr's stress circle? Draw the relevant force vector diagram in case of granular solids and show how the Mohr's stress circle is derived from this. **(10)**

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TYLER STANDARD SCREEN SIZES

Standard Interval = $\sqrt{2}$, Aperture, in.	Interval = $\sqrt[4]{2}$			
	Aperture, in.	Aperture, mm	Mesh Number	Wire Diameter, in
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	2½	0.088
0.263	0.263	6.680	3	0.070
	0.221	5.613	3½	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

Table for 1.(b)

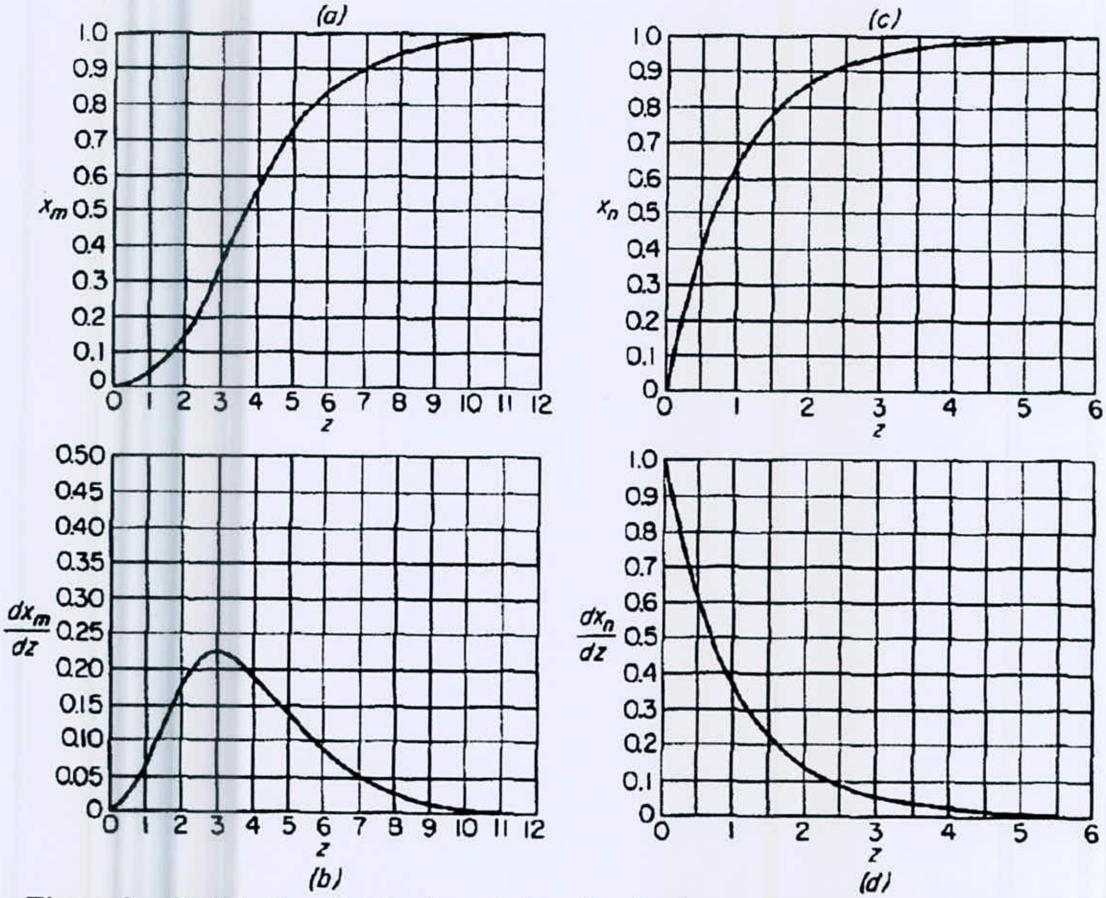

Figure for Q2 (b): Size-distribution relations in mixed suspension: (a) cumulative mass distribution; (b) differential mass distribution; (c) cumulative population distribution; (d) differential population distribution.

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Ergun Equation:

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

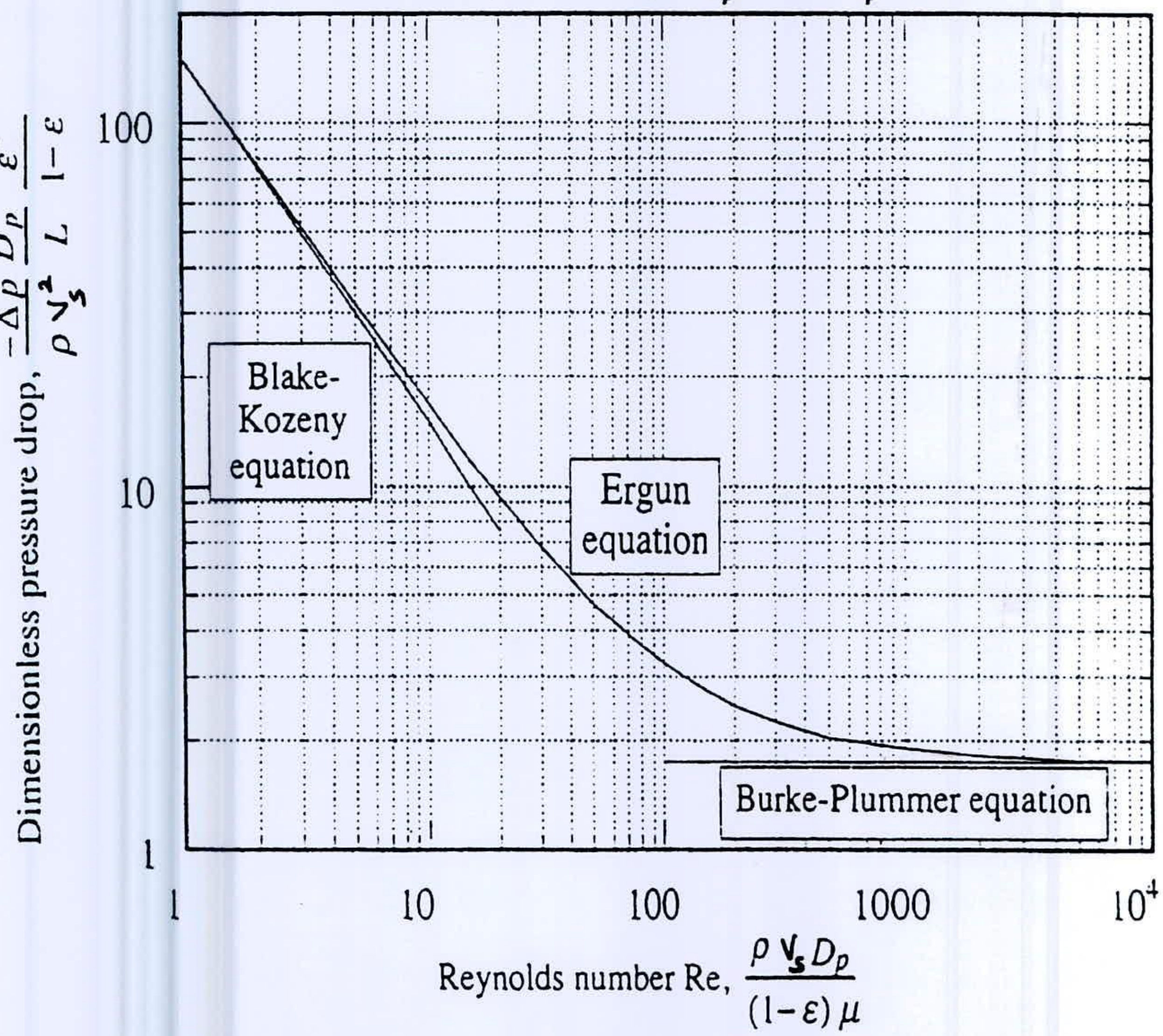

Figure for Q4: **Packed bed friction factor curve**

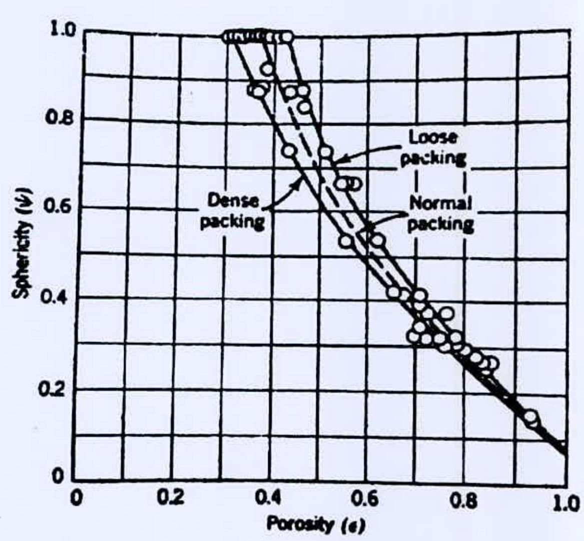

Figure: Sphericity as a function of porosity

Figure for Q.4

L-3/T-2/CHE **Date : 12/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2021-2022

Sub : **CHE 441** (Fertilizer, Pulp and Paper 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**.

The symbols have their usual meanings if not explained.

1. (a) Describe the process of mixed pulp (mechanical and chemical) production from softwood chips using a block diagram of the process. **(20)**

(b) Why do you need tertiary treatment of liquid effluent from a pulp and paper mill? **(5)**

(c) Mechanical pulping gives a high yield of pulp more than 90% while chemical pulping yield is not more than 40%. Why is that? Explain. **(7)**

(d) What type of bond is formed among the cellulose fibers in a paper? **(3)**

2. (a) Describe the purpose of using functional and control additives for paper making process. Is the additive for increasing dry strength of paper categorized as functional or control additive? **(7+2=9)**

(b) Explain the reasons for having a recovery boiler in kraft pulping process. Is there any alternative to recovery boiler? **(4+2=6)**

(c) Describe the process of chemical recovery cycle (starting from liquor evaporation to regeneration of white liquor and lime) with a schematic diagram of the process. **(20)**

3. (a) What are the possible sources of solid and gaseous emission from a pulp and paper mill? How can you mitigate the solid and gaseous emissions from the process? **(4+6=10)**

(b) In the paper production process, describe the function of deculator and cleaners for pulp (primary, secondary, and tertiary). What is the function of a pressure screen? **(8)**

(c) A certain pulp is bleached in the following sequence: CEHP. What do you understand by this? Draw a sketch of the possible stages involved in this process. **(3+6=9)**

(d) "Pulp and paper mills are perfect examples of bio-refinery." – clarify this statement by describing the product spectrum from a pulp and paper mills. **(8)**

4. (a) Briefly describe the grade and quality of the following types of papers: **(4×5=20)**

(i) Coated wood-free paper, (ii) Newsprint, (iii) Bond paper, (iv) Uncoated ground wood, (v) Fine papers.

(b) Describe the function of a blow tank during chemical pulping. **(5)**

Contd P/2

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(c) Based on chemical analysis performed on a liquor solution for pulping, it was found that it comprised of 15g NaOH, 5g Na_2S, 3g Na_2CO_3 and 2g Na_2SO_4 in aqueous solution of 1 liter. Express the active Alkali (AA) content of this solution as Na_2O. **(10)**

SECTION – B

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

5. (a) Explain the function of Nitrogen, Phosphorus, and Potassium as plant nutrients. **(12)**

   (b) Briefly discuss the current demand and production scenario of urea fertilizers in Bangladesh. **(8)**

   (c) Briefly discuss the routes for syngas preparation for ammonia synthesis. Compare the routes based on energy consumption, economics, and sustainability. **(15)**

6. (a) Discuss down the effect of the steam/carbon ratio for primary reformer operation. **(5)**

   (b) State the reasons for the modification of conventional Primary Reformer. Explain how Haldor Topsøe Exchange Reformer modifies the conventional reforming process with a proper process flow diagram. **(10)**

   (c) Explain why purge gas recovery is important for the ammonia production process. Describe the process for ammonia and hydrogen recovery from the purge gas with process block diagrams. **(3+12)**

   (d) Differentiate between the atmospheric and pressure storage for ammonia. **(5)**

7. (a) Explain the process of uptake of nutrients by plants from urea fertilizer. **(10)**

   (b) State the purpose of the carbamate condenser in the Stamicarbon process of urea production. **(7)**

   (c) Compare the prilling and granulation processes for urea production. **(10)**

   (d) Explain why boiler feed water (BFW) treatment is necessary. Describe the deaeration process for BFW treatment. **(3+5)**

8. (a) Outline the factors affecting the phosphate rock quality. **(10)**

   (b) Describe the Diammonium Phosphate (DAP) production process with a proper process flow diagram. **(15)**

   (c) Analyze the potential pollution problems and their abatement processes associated with TSP production. **(10)**

L-3/T-2/CHE **Date : 07/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

B. Sc. Engineering Examinations 2021-2022

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Briefly discuss the development of industrial production process of Penicillin. **(15)**

(b) How does Enzyme function? Discuss Enzyme as a catalyst. **(10)**

(c) Discuss Michaelis-Menten model of enzyme kinetics. Develop Mechanistic Model of Simple Enzyme Kinetics for Rapid Equilibrium Assumptions. **(10)**

2. (a) What is Antibody? Briefly discuss antibody structure, their functions and biotechnological applications. **(15)**

(b) Write down the typical population of the following microorganisms in culture: Viruses, Bacteria, Yeast, small unicellular Algae. **(10)**

(c) What is Cell Nutrients? Briefly discuss the physiological function and required concentration of the major macronutrient elements. **(10)**

3. (a) Briefly explain the structure and classifications of Amino Acids as protein building blocks. **(15)**

(b) Briefly discuss Steroids and their applications. Give examples of different Steroids. **(10)**

(c) Explain classification technique and structural differences of Bacteria on the basis of Gram Reaction. **(10)**

4. (a) Discuss the procedures for determining of rate parameter K_m and V_m for a simple enzyme-catalyzed reaction using (i) Eadie-Hofstee Plot and (ii) Hanes-Woolf Plot. **(12)**

(b) Explain temperature effect on Enzyme Denaturation with appropriate equations and graphical representation. **(8)**

(c) Scientists have studied the hydrolysis of sucrose at pH = 4.5 and 25°C using crude invertase obtained from baker's yeast in free and immobilized form. The following initial velocity data were obtained with 4.8 units of crude enzyme (1 unit = quantity of enzyme hydrolyzing 1 μmol of sucrose/min when incubated with 0.29 M sucrose in a buffer at pH 4.5 and 25°C. **(15)**

Contd.........P/2

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(i) Determine k_m and V_m for this reaction using both free and immobilized Enzyme.

(ii) What kind of inhibitor is this? Substantiate the answer.

V_0 (mmol hydrolyzed/l-min)		S_0 (mol/l)
Free Enzyme	Immobilized Enzyme	
0.083	0.056	0.010
0.143	0.098	0.020
0.188	0.127	0.030
0.222	0.149	0.040
0.250	0.168	0.050
0.330	0.227	0.100
0.408	0.290	0.290

SECTION – B

There are **FOUR** questions in this section. Answer Question No. 05 is as **COMPULSORY** and 45 marks. Answer any **TWO** from the rest.

5. (a) "ELISA is a simple, yet sensitive quantifiable technique that has versatile applicability" – explain this statement with proper justification. **(9)**

(b) Discuss the five major types of food spoilage that involve chemical reactions. **(15)**

(c) What is the most suitable method to sterilize industrial wet air? Justify your answer by explaining why the other methods wouldn't work. **(10)**

(d) What are the issues you may encounter in an Activated Sludge Process? Discuss the possible modifications to address those issues? **(5+6=11)**

6. (a) With neat schematic explain the mechanism of C-ELISA technique. Discuss a scenario where C-ELISA is more preferable than the other-techniques. **(9)**

(b) What are the basic requirements for the processing of foods for irradiation? **(6)**

(c) A continuous sterilizer with a steam injector and a flash cooler will be employed to sterilize medium continuously with the flow of 2 m^3/hr. The time for heating and cooling is negligible with this type of sterilizer. The typical bacterial count of the medium is about $5\times10^{12} m^{-3}$, which needs to be reduced to such an extent that only one organism can survive during two months of continuous operation. The heat-resistant bacterial spores in the medium can be characterized by an Arrhenius coefficient of $5.7\times10^{39} hr^{-1}$ and an activation energy (E_d) of 2.834×10^5 kJ/kmol. The sterilizer will be constructed with the pipe with an inner diameter of 0.102 m. Steam at 600 kPa (gage pressure) is available to bring the sterilizer to an operating temperature of 125°C. The physical properties of this medium at 125°C are: c = 4.187 kJ/kg K, ρ = 1000 kg/m^3, and μ = 4 kg/m/hr. What length should the pipe be in the sterilizer if you assume ideal plug flow? **(15)**

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7. (a) What is the benefit of Gas sterilization? Briefly discuss the key features of Ethelene Oxide and H_2O_2 based gas sterilization. **(8)**

(b) Briefly explain 'water activity' in food. What are the differences among 'D-value', F-value' and 'z-value' in the context of sterilization? **(3+6=9)**

(c) Draw a PFD of the Moving Bed Biofilm Reactor (MBBR) process and label the components. List the salient features of a MBBR. **(4+4=8)**

(d) With an appropriate plot explain the Glass transition temperature effects on the shelf life of food products. **(5)**

8. (a) What do you understand by Biosafety Level? Briefly discuss the salient features of each of these levels. **(2+8=10)**

(b) "Chilling is often preferred over food preservation method" – Justify this statement. **(5)**

(c) An industrial waste with an inlet BOD_5 of 800 mg/l must be treated to reduce the exit BOD_5 level less than 20 mg/l. The inlet flow rate is 400 m^3/h. Kinetic parameters have been estimated for waste as mm = 0.20 h^{-1}, K_s = 50 mg/l of BOD_5, Y^M_{XS}= 0.5 mg MLVSS/mg BOD_5, and K_d = 0.005 h^{-1}. A waste treatment unit of 3200 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? If required, derive the required equation from the given equations. **(5+5+5=15)**

Cells' residence time =

$$\theta_c = \frac{1}{\mu_{net}} = \frac{VX}{F(1-\gamma)X_e + FX_r}$$

Required volume of the sludge tank =

$$V = \frac{Y^M_{X/S} F(S_0 - S)}{\mu_{net} X} = \frac{Y^M_{X/S}\theta_c F(S_0 - S)}{X(1 + k_d \theta_c)}$$

The system is shown in Figure 8(c).

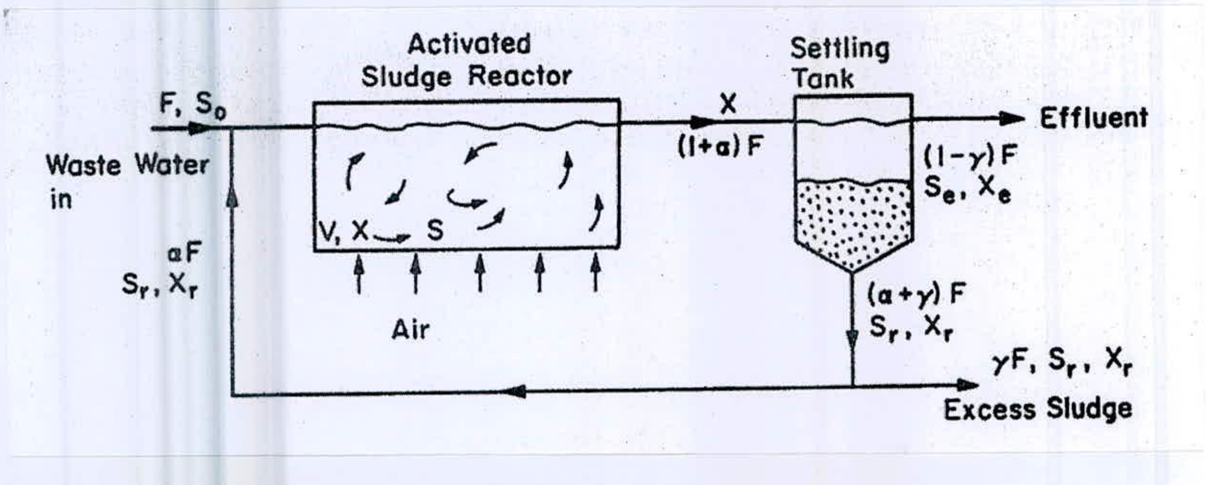

Figure 8(c)

L-3/T-2/CHE **Date : 07/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

B. Sc. Engineering Examinations 2021-2022

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer **Question No. 1** is **Compulsory** and Answer any **TWO** from the rest.

Assume any reasonable value for missing data and note it clearly in the answer script.

1. (a) Analyze the forces on colloids with illustrations. Clearly note the energy barrier and the ways to overcome it briefly. **(13)**

(b) Compare the different types of particle settling with examples. Diagrammatically explain how the settling velocity changes with time. **(15)**

(c) Classify industries based on ECR 1997. How can you get a clearance certificate for a red-category industry? **(7)**

2. (a) An industrial process discharges its effluent into a stream. It is desired to determine the effects of the waste discharge on the dissolved oxygen concentration of the stream. k_1 and k_2 at mixing temperature are 0.226 d^{-1}, and 0.427 d^{-1}, respectively. The characteristics of the stream and industrial wastewater are given below. Assume a reasonable value if it isn't specified. You don't need to derive any necessary equations if you can memorize them. **(25)**

Characteristics	stream	industrial wastewater
Flow rate, m^3/s	6.5	0.5
Temperature, °C	19.2	25
Dissolved oxygen, mg/L	8.2	0.5
BOD_5 at 20°C	3.0	200

(i) Calculate the critical values and the distance from the point of discharge at which the critical values will occur. The steam velocity is 0.2 m/s.

(ii) Calculate the values and draw the dissolved oxygen sag curve for a100 km reach of the stream from the point of discharge.

(b) If 250mg/L of ferric chloride is added for coagulation, how much alkalinity is consumed in mg/L as $CaCO_3$? **(10)**

3. (a) A wastewater contains sand particles of three major sizes: 0.002 mm, 0.6 mm, and 60 mm. A settling basin is designed to achieve 100% removal of 0.6 mm diameter particles. Assume the water temperature is 25°C. How much removal can be achieved

Contd.........P/2

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Contd... Q. No. 3

for the other particle sizes? All the steps should be noted clearly in your answer. Fluid properties won't be supplied. **(18)**

$$R_e < 1, C_d = \frac{24}{\text{Re}}$$

$$1 < \text{Re} < 10^3, C_d = \frac{24}{\text{Re}} + \frac{3}{\sqrt{\text{Re}}} + 0.34$$

$$\text{Re} > 10^3, C_d = 0.4$$

(b) Illustrate the biological nitrogen removal process mentioning all the reactions and microorganisms involved in the process. What are the relations between Free ammonia and ammonium ion with respect to pH and Temperature? A proper diagram in your answer is required. **(17)**

4. (a) What are the types of adsorbent? 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 30 mg/L. The flasks were agitated for 17 h, and the residual, steady-state TOC concentrations were determined. Plot the Langmuir adsorption equilibrium from the data presented below and determine the values of the appropriate constants. **(20)**

Flask No.	Carbon Dosage (mg)	Final TOC (mg/L)
1	0	30
2	4.4	24
3	9.7	20
4	14	17
5	28	14
6	56	12.6
7	140	10.8

(b) Write short notes on the followings: (any five) **(15)**

(i) Impact of sulfur-containing compounds in wastewater

(ii) Significance of BOD/TKN ratio

(iii) Significance of BOD/COD ratio

(iv) Anoxic process

(v) SVI

(vii) Food to microorganism ratio

(viii) MLVSS

SECTION – B

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

5. (a) Describe the process of formation of ozone in the stratospheric ozone. Explain how it contrasts with the formation of urban ozone. **(4+4=8)**

(b) Demonstrate the reaction pathways that lead to the formation of secondary pollutants. Discuss the formation of photochemical smog and relate the steps with the reaction pathways. **(6+6=12)**

(c) Explain why maximum noise limits vary in different zones. Discuss the optimum location for the installation of the barrier for noise pollution control. **(3+4=7)**

(d) Briefly discuss about occupational noise pollution and propose ways to control occupational noise pollution. **(4+4=8)**

6. (a) Write a short note on the effect of air pollution on climate. **(8)**

(b) An air stream with a flow rate of 7 m^3/s is passed through a cyclone with inlet width, W_i = 0.5 m, and inlet Height, H=1 m, respectively. The number of turns is 5. The particle diameter is 10 microns with a density of 1.5 g/cc. The viscosity of air is 2.1×10^{-5} kg/m.s. Compute the particle removal efficiency using both block flow and mixed flow models. State all the assumptions considered. **(12)**

(c) Discuss the techniques of control of NOx emissions in combustion gases. **(10)**

(d) Compare water absorbing with other scrubbing agents for the removal of SO_2 from lean waste gases. **(5)**

7. (a) An offshore oil platform is venting natural gas (assume it is all methine) at a rate of 150 L/sec through a stack with a diameter of 15 cm at a height of 45 meters above the sea. The stack gas exit temperature and pressure are 40°C and 101.3 KPa, respectively. The wind is blowing at 4 m/s at 10 m height. Assume, it is night-time with overcast conditions and the terrain is smooth (p=0.6). **(18+7=25)**

(i) Considering plume rise (For the calculation of plume rise, use wind velocity at stack height), calculate methane concentration (mg/m^3) 500 meters downwind along the centerline (a) at sea level, and (b) 50 m above the water.

Atmospheric conditions

Temperature:25°C

Pressure: 1 bar

(ii) A helicopter is ferrying oil workers to the platform. A spark plug wire is loose on the engine, making the aircraft a possible source of ignition (thanks to dual ignition, the engine is running fine). The helicopter approaches the oil platform from directly downwind, coming to within 100 m of the platform, analyze whether this is safe, or could the plume ignite?

Contd.........P/4

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Contd... Q. No. 7

The lower flammability limit of methane in air is 5 mol%

The required formulae and figures are attached.

(b) State the limitations of the fixed box model and propose modifications to improve the model. **(10)**

8. (a) Identify the type of plume which is the most dangerous for ground-level pollution. Explain the plume type with temperature profile, plume dispersion diagram, typical occurrence and wind conditions. **(12)**

(b) "AQI in Dhaka city is found to be very unhealthy during the winter season" - Explain this with the concept of atmospheric stability. **(6)**

(c) Explain the process for determination of SO_2 concentration in stack gas. **(10)**

(d) Discuss the difficulties associated with stack pollution measurement if the sampling is non-isokinetic with diagrams. **(7)**

=5=

Surface wind speed (at 10 m), m/s	Day			Night	
	Incoming solar radiation				
	Strong	Moderate	Slight	Thinly overcast or ≥ $\frac{4}{8}$ cloud	Clear or ≤ $\frac{3}{8}$ cloud
0–2	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

Source: Ref. 7.
Note: The neutral class D should be assumed for overcast conditions during day or night.

Table for Q 7(a)

Required formula for Q7(a)

$$\Delta h = \frac{V_s D}{u}\left(1.5 + 2.68 \times 10^{-3} PD \frac{(T_s - T_a)}{T_s}\right)$$

Here,

V_s= Stack Exit velocity in m/s

D= Stack Exit Diameter in m

u= wind speed at stack height in m/s

P= Stack gas exit pressure in milibars

T_s= Stack exit temperature in K

T_a= Atmospheric Temperature in K

=6=

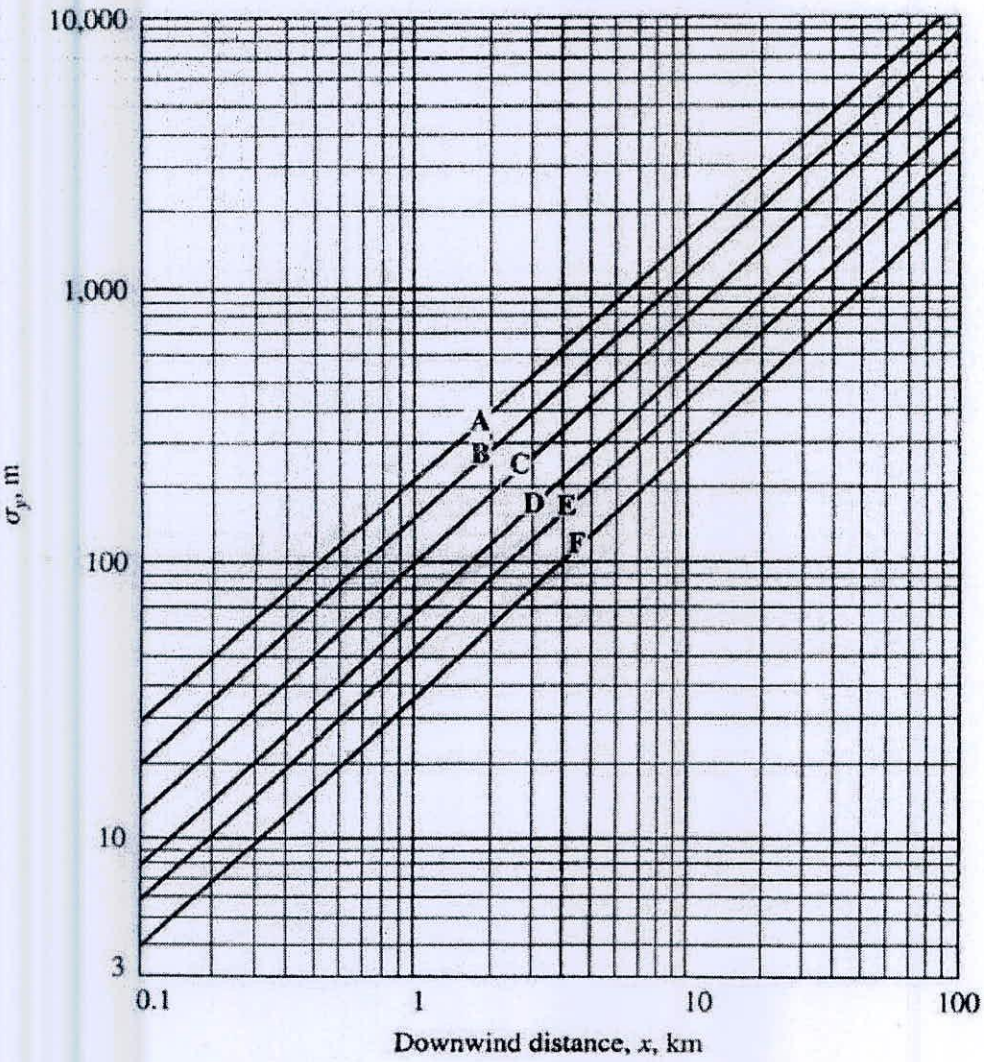

Figure for Q 7(a)

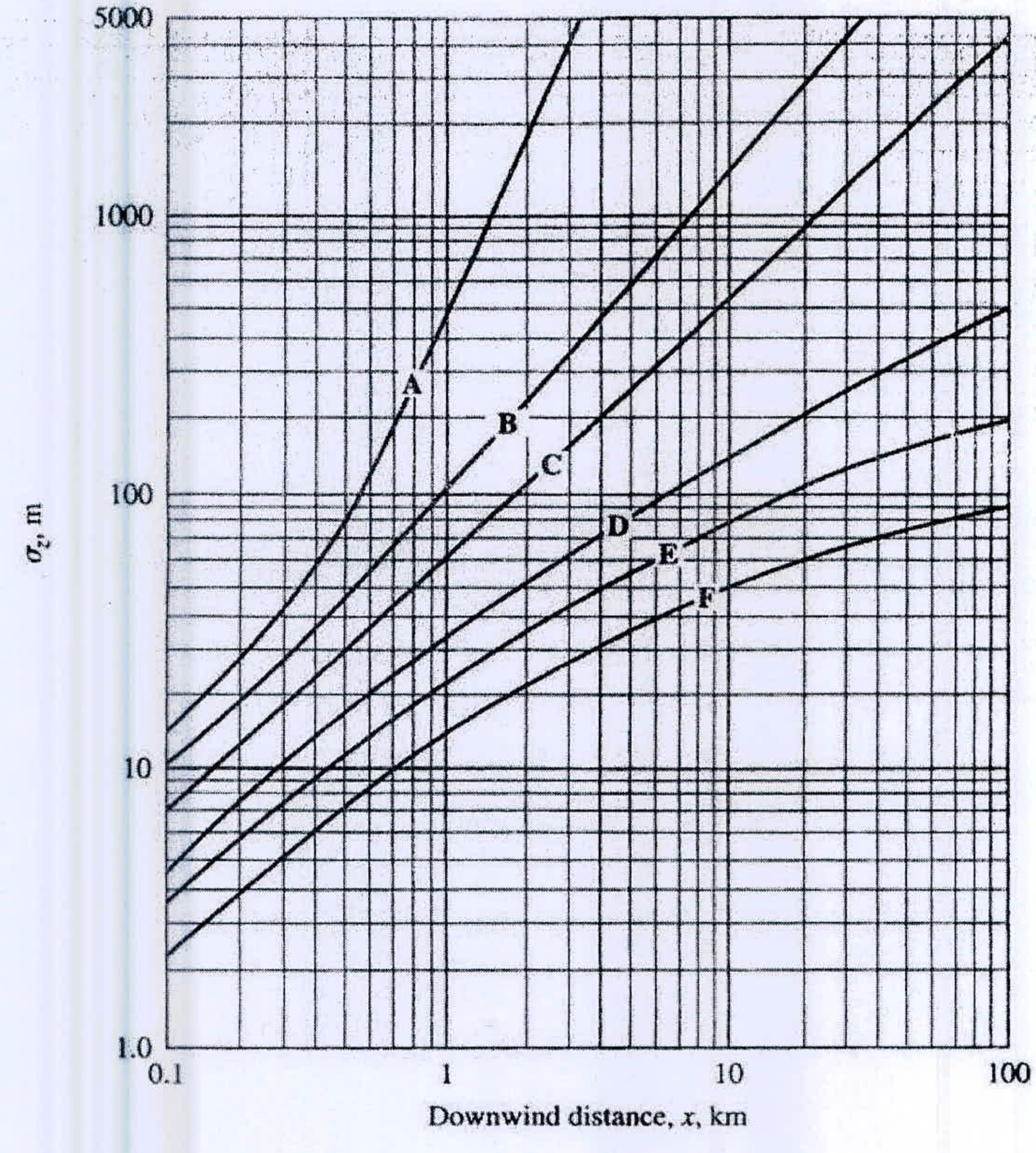

Figure for Q 7(a)