L-3/T-2/CHE **Date : 20/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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 any **THREE**.

1. (a) Derive the basic equation of mass transfer for isothermal adsorption in fixed beds. Obtain the concentration profile in case of irreversible adsorption from the derived equation. **(15)**

(b) An industrial wastewater contains 10 mg/L chlorophenal, and will be treated by adsorption on activated carbon. The wastewater is discharged at a rate of 0.1 MGD (million gallons per day). If 90% removal is desired calculate the carbon requirement for **(20)**

(i) a single mixed contactor i.c. stirred tank

(ii) a fixed bed contactor with 10% unused bed.

Freundlich isotherm for the activated carbon is of $q = 6.74C^{0.41}$

hence, $q = \frac{\text{mg of chlorophenal}}{\text{gm of C}}$

$c = \frac{\text{mg of chlorophenal}}{\text{L of Wasterwater}}$

(Given: 1 US liquied gallon = 3.785 liter)

2. (a) In pervaparation the VLE is quite different from the VLE in distillation – justify this statement with the help of mass flux equation. **(8)**

(b) Distinguish between dialysis and electro dialysis. **(7)**

(c) Laboratory tests of a membrane for H_2/CH_4 separation gave a permeate composition of 80 percent H_2 and a residue of 42 percent H_2 when the feed had 50 percent H_2 and feed and permeate absolute pressure were 100 and 15 Psi, respectively. The permeate flow was 20 percent of the feed flow. **(20)**

(i) What is the membrane selectivity?

(ii) About what permeate composition would have been obtained if a vacuum had been used on the downstream side?

3. (a) A packed counter current water-cooling tower using a gas flow rate of G = 1.356 kg dry air/s-m^2 and a water flow rate L = 1.356 kg water/s-m^2 is to cool the water from T_{L2} = 43.3°C (110°F) to T_{L1} = 29.4°C (85°F). The entering air at 29.4°C has a wet bulb temperature of 23.9°C. The mass transfer coefficient k_La is estimated as 1.207×10^{-7} kg mol/s.m^3.Pa. Calculate the height of the packed tower. The tower operates at a pressure of 1.013×10^5 Pa. **(35)**

(see the attached table and humidity- Temperature chart)

Contd P/2

CHE 305

4. (a) What is Knudsen diffusion? How do you calculate effective diffusivity in case of Knudsen diffusion? **(8)**

(b) Describe the working principle of a Pressure Swing Adsorber (PSA). **(9)**

(c) Draw the breakthrough curves for ideal and real case fixed bed adsorption. Explain each curve. **(9)**

(d) Identify the types of mass transport involved in Reverse osmosis. Write down the mass transfer equations for both water and salt at steady state and explain each term. **(9)**

SECTION-B

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

5. (a) The gas ammonia (A) is diffusing at steady state through N_2(B) by equimmolar counter diffusion in a conduit 1.22 m long at 25 °C and a total pressure of 101.32 KPa abs. The partial pressure of ammonia at the left end is 25.33 KPa and the other end 5.066 KPa. The cross section of the conduit is in the shape of an equilateral triangle, the length of each side of the triangle being 0.0610 m at the left end and tapering uniformly to 0.0305m at the right end. Calculate the molar flux of ammonia. The diffusivity is $D_{AB} = 0.230 \times 10^{-4} m^2/s$. **(20)**

(b) Carbon dioxide is being scrubbed out of a gas using water flowing through a packed bed of 1 cm Berl saddles. The carbon dioxide is absorbed at rate of $2.3 \times 10^{-}6$ mol/cm^2/sec. The carbon dioxide is present at a partial pressure of 10 atm, the Henty's law coefficient of carbon dioxide is 600 atms and the diffusion coefficient of carbon dioxide in water is 1.9×10^{-5} cm^2/sec. Find the film thickness. **(15)**

6. (a) A drop of liquid toluene is kept at a uniform temperature of 25.9 °C and is suspended in air by a fine wire. The initial radius is $r_1 = 2.00$ mm. The vapor pressure of toluene at 25.9 °C is $P_{H1} = 3.84$ KPa and the density of liquid toluene is 866 kg/m_3. **(18)**

(i) Derive an equation to predict the time t_F for the drop to evaporate completely in a large volume of still air. Show all steps.

(ii) Calculate the time in seconds for complete evaporation.

(b) What are HETP and NTU? Derive the relationship between HETP and NTU for two different conditions of operating and equilibrium lines. **(17)**

7. Ammonia is being absorbed from a reactor gas stream, which can be considered to be inert air at 68 °F and 1 atm, by pure water. The packed tower is operated with a water flow of 100 lbmol/hr and a total inlet gas flow of 85 lbmol air and ammonia/hr. The tower diameter is 2 ft. The inlet gas contains 4.0 mole percent NH_3 and the outlet contains 0.5 percent.

Contd P/3

CHE 305

Contd... Q. No. 7

From correlations for dilute solutions the average H_L has been estimated as 0.85 ft and the average H_G as 1.6 ft. The equilibrium data in mole fraction of NH_3 at 1.0 atm in the liquid and vapor as follows: **(35)**

x	y
0.0208	0.0158
0.0309	0.0240
0.0503	0.0418

(a) Plot the operating and equilibrium lines.

(b) Convert the H_G and H_L to $k'_y a$ and $k'_x a$

(c) Find the interface compositions.

(d) Calculate the number of transfer units and the tower height.

(Hint: For dilute solutions $\frac{(1-y)_{i,in}}{(1-x)_{i,in}} \cong 1$

and $\frac{(1-y)_{i,in}}{(1-y)} \cong 1$

8. (a) Briefly describe the concept of light key and heavy key components used in short-cut method for multi component distribution. **(8)**

(b) A mixture of 40 mole% benzene and balance ethyl dichloride can be separated by using a distillation column with a partial reboiler and a total condenser. The feed rate is 750 moles/h and feed is a saturated vapor. It is desired to attain a distillate product that is 99.2 mole% benzene and a bottoms product that is 0.5 mole% benzene. Reflux is a saturated liquid and constant molar overflow can be used. Equilibrium data can be approximated with an average relative volatility of 1.11 (benzene is more volatile). **(27)**

(i) Find the minimum external reflux ratio.

(ii) Use the Fenske equation to find the number of stages required at total reflux.

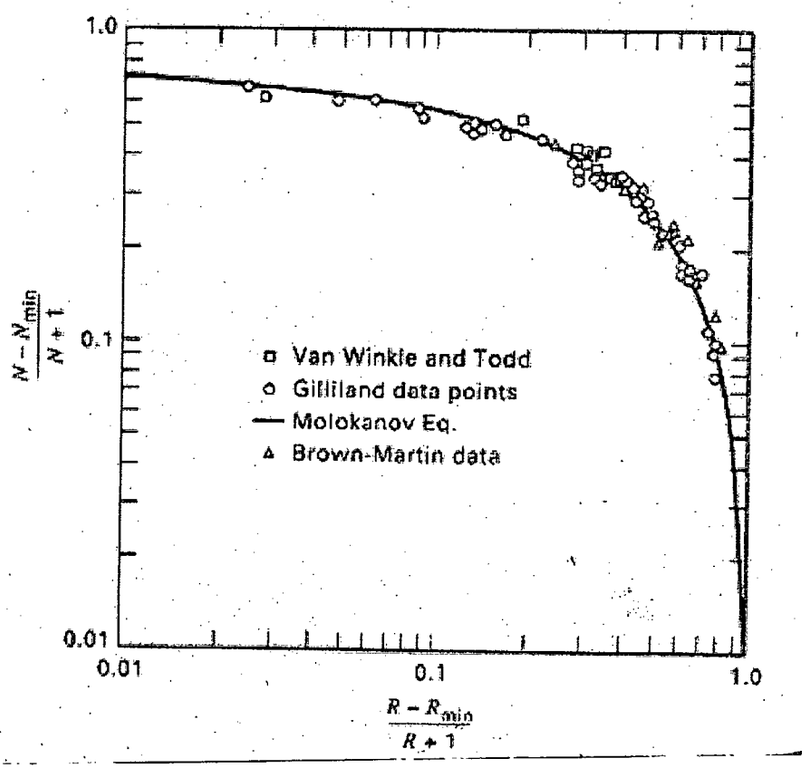
(iii) Estimate the total member of stages required for this separation, using the Gilliland correlation for $L/D = 1.2(L/D)_{min}$.

Table for Q No. 3

Enthalpies of Saturated Air–Water Vapor Mixtures
(0°C Base Temperature)

T_L		H_y		T_L		H_y	
		btu	J			btu	J
°F	°C	lb_m dry air	kg dry air	°F	°C	lb_m dry air	kg dry air
60	15.6	18.78	43.68×10^3	100	37.8	63.7	148.2×10^3
80	26.7	36.1	84.0×10^3	105	40.6	74.0	172.1×10^3
85	29.4	41.8	97.2×10^3	110	43.3	84.8	197.2×10^3
90	32.2	48.2	112.1×10^3	115	46.1	96.5	224.5×10^3
95	35.0	55.4	128.9×10^3	140	60.0	198.4	461.5×10^3

Table for Q No 8



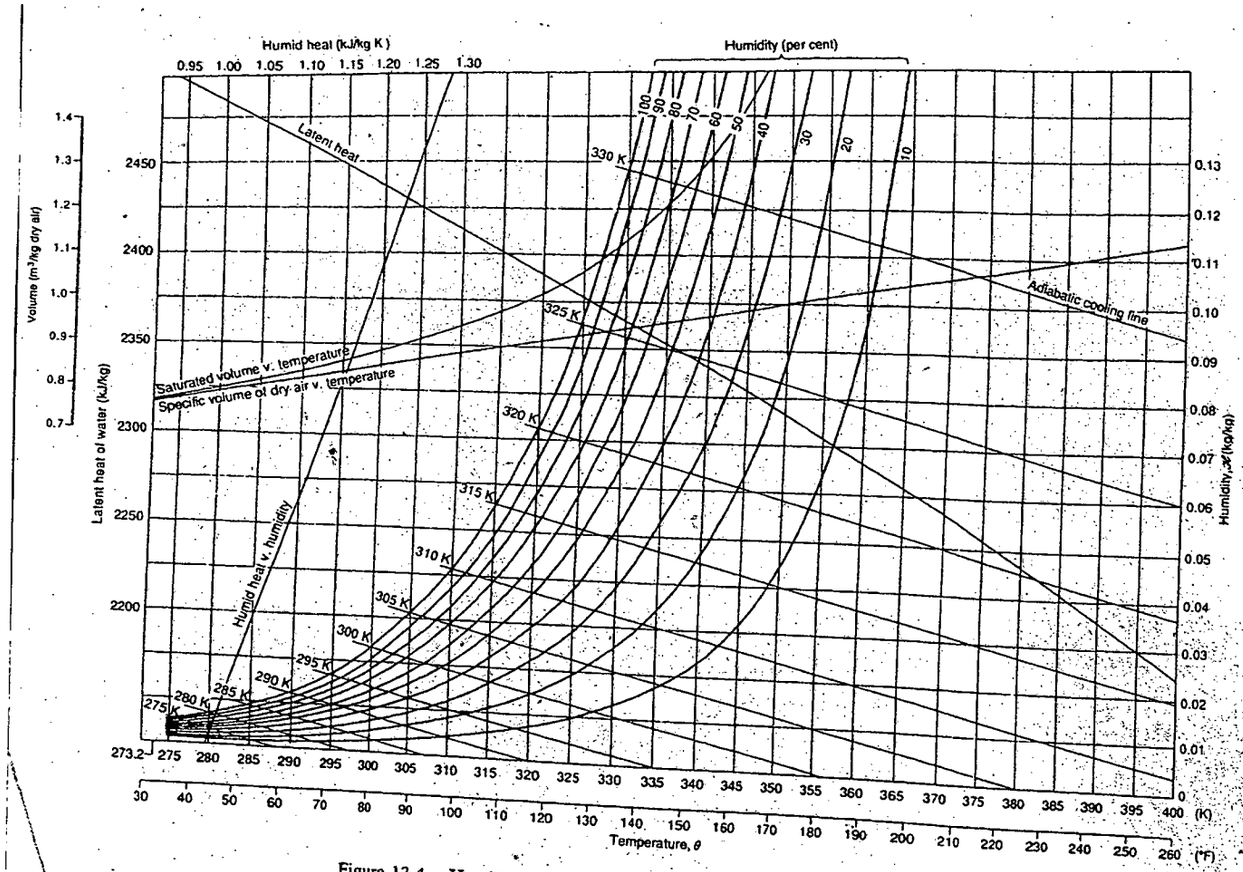


Figure 13.4. Humidity–temperature chart (See also the Appendix)

L-3/T-2/CHE **Date : 16/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 433** (Polymers & Petrochemicals)

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**.

1. (a) What is degree of polymerization? Explain with an example. **(5)**
   (b) Discuss in details the classification of polymers. **(25)**
   (c) Write a few words on molecular weight and its distribution in polymers. **(5)**

2. (a) What is polymerization process? **(5)**
   (b) How the synthetic fibre Nylon is manufactured from polymerization process **(20)**
   (c) Distinguish between chain and step-polymerisation mechanisms. **(10)**

3. (a) Describe the Kinetics of stepwise polymerization with necessary equations. **(18)**
   (b) Derive the number-distribution function for a linear stepwise polymerization at extent of reaction p. **(12)**
   (c) Show graphically the number of mole fraction distribution and weight fraction distribution of chain molecules in a linear step reaction polymer. **(5)**

4. (a) Discuss different types of copolymers. **(6)**
   (b) Write Kinetics of copolymerization. **(22)**
   (c) Derive necessary equations to calculate instantaneous composition of feed and polymer. **(7)**

SECTION-B

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

5. (a) Elaborate the derivation of petrochemicals from all the three main sources. **(10)**
   (b) Signify the importance of synthesis gas in the context of petrochemicals. **(7)**
   (c) Describe the UOP cumox process for phenol production from cumene. **(10)**
   (d) Cyclohexane is used almost exclusively in the production of intermediates for nylon fiber and resins, with 60 percent to nylon 66 and 30 percent to nylon 6 – Justify. **(8)**

Contd P/2

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Contd... Q. No. 6

6. (a) Describe the generally accepted theory and history of petroleum crude oil formation. **(12)**

(b) Write down a technical note on crude Oil Extraction. **(8)**

(c) Elaborate the importance of cycloparafins. **(5)**

(d) Discuss solvent extraction method to reduce the concentration of heavy metals in petroleum residues. **(10)**

7. (a) In the context of refining natural gas and crude oil, explain principle, importance and limitation of the follows: **(3×8=24)**

(i) Steam Cracking

(ii) Vacuum Distillation

(iii) Isomerisation.

(b) Explain properly the recovery of condensable hydrocarbon by week oil extraction method. **(11)**

8. (a) Demonstrate Selenol process for the removal of acid gas from natural gas mixture. **(12)**

(b) Make a comparison between Merox and Sulfinol processes used for removing sulfur from natural gas. **(8)**

(c) Write a short note on – **(5×3=15)**

(i) Acetylene

(ii) Detergent

(iii) Olefin.

L-3/T-2/CHE **Date : 16/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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 any **THREE**.

1. (a) Discuss the impact of raw materials and technology on the quality of paper manufacturing. What is the situation now in Bangladesh? **(12)**

   (b) Briefly outline the measures to be taken to combat liquid pollution from Kraft pulping process. What effluent discharge standard you would follow? **(10)**

   (c) Explain the basic structure of wood from pulping point of view. **(8)**

   (d) "Bleaching is a continuation of continuous digestion process". Justify the statement. **(5)**

2. (a) Discuss important pulping variables of wood and wood chips. **(10)**

   (b) Explain the mechanism of grinding in SGW and RMP pulping. **(7)**

   (c) Compare mechanical and chemical pulping processes. Name some specific uses of mechanical pulp. **(10)**

   (d) "TMP is referred to as the most important mechanical pulping method". Defend the statement. What happens if steaming temperature is more than 145 °C during TMP pulping? **(8)**

3. (a) Give a neat sketch of a Fourdrinier Machine. Explain its working principle. **(13)**

   (b) Discuss the different steps that involved in spent liquor recovery from Kraft process. **(12)**

   (c) Write short notes on the following: **(5×2=10)**

   (i) H-factor
   (ii) R_{oe} number
   (iii) Total and effective alkali
   (iv) Hemicelluloses
   (v) Lignin

4. (a) Describe Kraft pulping process with an appropriate flow diagram. **(12)**

   (b) Describe DAP manufacturing process. What are the advantages of DAP over TSP? **(9)**

   (c) What is NPK fertilizer? Describe NPK production from ammonia, phosphoric acid, urea and potash as raw materials. **(8)**

   (d) Discuss the role of additives in paper manufacture ting process. **(6)**

Contd P/2

CHE 441

SECTION-B

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

5. (a) Define plant nutrients and classify them. Explain specific effects of primary plant nutrients in plants. Write down the advantages of liquid fertilizer over dry fertilizer. **(11)**

(b) Name the Ammonia-Urea complexes in Bangladesh along with their locations, capacity, year of commissioning and technologies used. **(12)**

(c) Write a short note on catalysts used in ammonia-urea production. **(6)**

(d) Justify the use of two separate shift converters instead of one large converter in ammonia production. **(6)**

6. (a) Why steam-methane reforming reaction is carried out at high pressure condition for ammonia production? **(5)**

(b) Discuss the thermodynamic and Kinetic aspects of different steps that are involved in ammonia synthesis. **(15)**

(c) Explain the following-

(i) Ammonia production process is an energy generating process. **(2)**

(ii) Carbon dioxide is charged to stripper rather than urea reactor. **(2)**

(iii) Secondary reformer is used along with primary reformer in ammonia production. **(3)**

(iv) Urea is made by a two step reaction of ammonia with carbon dioxide. **(2)**

(d) Discuss the phenomena involved inside a prilling tower. **(6)**

7. (a)Give comparison between Satamicarbon and Snamprogetti total recycle processor for urea production. **(10)**

(b) Describe the one-through process in urea production along with a process flow diagram. **(6)**

(c) Write a short note on "pollution and pollution control" in an Ammonia-Urea complex. **(10)**

(d) What are the active chemicals present in Benfield solution? What are the functions? **(5)**

(e) State some properties of urea that are of interest for fertilizer use. **(4)**

8. (a) Describe the manufacturing process of muriate of potash from sylvite ore. **(10)**

(b) Outline some of the factors affecting phosphate rock quality. **(8)**

(c) How much gypsum is produced per ton of phosphoric acid production? State the problems related to gypsum disposal. **(5)**

(d) What are the different processes available for manufacturing of phosphoric acid. Write down the reactions taking place in those processes. Also draw the block diagram (PDB) for hemihydrates. **(12)**

L-3/T-2/CHE **Date : 16/07/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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

Full Marks: 280 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**.

1. (a) A Swenson walker crystallizer is to be used to produce 1 ton/hr of copperas ($FeSO_4.7H_2O$) crystals by the cooling of a saturated solution which enters the crystallizer at 120° F. The slurry leaving crystallizer will be at 80° F. Solubility data are given in Figure for Q. 1(a). Cooling water enters the crystallizer jacket at 50° F and leaves at 75° F. It may be assumed that the overall coefficient of heat transfer for crystallizer is 35 Btu/(hr) (sq.ft) (°F). There are 3.5 sq.ft of cooling surface per foot of crystallizer length. Average specific heat of initial solution is 0.70 Btu/ (lb) (°F) and heat of solution of $FeSO_4.7H_2O$ at 18 °C = - 4400 cal/g formula weight. **(25)**

   (i) Estimate the amount of cooling water required in gpm.

   (ii)Determine the number of crystallizer sections to be used.

   (b) Discuss the factors to be considered in designing crystallizer processes. **(10)**

   (c) With the help of neat sketch of a mixing tank write the different shape factors for turbine design. **(11⅔)**

2. (a) A centrifugal pump takes brine from the bottom of a supply tank and delivers it to the bottom of another tank as shown in Figure for Q. 2(a). The brine level in the discharge tank is 50 m above that in the supply tank. The tanks are connected by 200 m of 18 cm diameter steel pipe. The flow rate is 50 liters/s. The line between the two tanks has two gate valves, four standard tees and two 90° elbows. The pipe has a roughness of 0.04 mm. What is the power requirement for the pump with an overall efficiency of 60 %? Make necessary assumptions and state them. **(32)**

   Data: Density of brine = 1180 kg/m^3

   Viscosity of brine = 1.2×10^{-3} kg/m.s

Pipe fittings:	Equivalent L/D
Gate valve	7
90° Elbow	32
Tee	90

   (b) What are the common problems of a centrifugal pump and how are the prevented? **(14⅔)**

Contd P/2

CHE 311

3. (a) Discuss the applications, relative advantages and disadvantages of different types of feed arrangements to multiple effect evaporator systems. Show the feed arrangements with the help of neat sketch of each type. **(20)**

(b) Discuss the effect of feed state on the evaporator capacity. **(12)**

(c) An agitated vessel 6 ft in diameter contains a six blade straight-blade turbine 2 ft in diameter, set one impeller diameter above the vessel floor, and rotating at 80 rpm. It is proposed to use this vessel for neutralizing a dilute aqueous solution of NaOH at 70° F with stoichiometrically equivalent quantity of concentrated nitric acid. The final depth of liquid in the vessel is to be 6 ft. Assuming that all the acid is added to the vessel at one time, how long will it take for the neutralization to be completed? **(14⅔)**

4. (a) With the help of simple schematic diagrams discuss the working principle, relative advantages and disadvantages of (i) Conveyor dryer, (ii) Tunnel kiln (iii) Rotary dryer, and (iv) Fluidized bed dryer. **(24)**

(b) Discuss different compressor performance characteristics with the help of the relevant diagrams. **(22⅔)**

SECTION-B

Answer **Q. No. 5** which is **compulsory** and carries 60 Marks.
Answer any **TWO** from the rest

5. (a) Answer the following (True/False, fill in the gaps, multiple choice where applicable) **(20)**

(i) Relief system is required to prevent damage to equipment not to prevent damage to adjoining properly, T/F

(ii) All vessels in a process industry need relief system. T/F

(iii) In standard spring operated relief valve, ------ and ------ through the valve are dependent on back pressure.

(iv) What is the function of governor in a steam turbine?

(a) Regulate the speed,
(b) Regulate the power,
(c) Control the steam flow,
(d) All the above.

(v) In steam turbine, steam expansion only happens at nozzle. T/F

(vi) In reaction turbine, both ----- drop and ----- rise occurs at blade passages.

(vii) Maximum blade efficiency of a impulse turbine depends only on inlet velocity and mean blade velocity. T/F

(viii) From energy utilization point of view, size reduction is very inefficient. T/F

(ix) Which type of force is used in size reduction?

(a) Impact
(b) Shear
(c) Compression
(d) All of the above
(e) None of the above.

Contd P/3

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Contd... Q. No. 5

(b) How will you estimate energy consumed in a comminution process? Use applicability of laws of size reduction. **(10)**

(c) What are the advantages and disadvantages of wet grinding? **(10)**

(d) What are the advantages of mechanical conveyors? Discuss the limitations of belt conveyors. **(10)**

(e) How will you differentiate Impulse and reaction turbine? **(10)**

6. (a) Discuss the major safety elements of a steam turbine. **(10)**

(b) The velocity of steam leaving the nozzles of an impulse turbine is 900 m/s and nozzle angle is 20°. The blade velocity coefficient is 0.7 and speed ratio $\rho = 1/3$. For a mass flow of 1 kg/s and symmetrical blading, calculate **(30)**

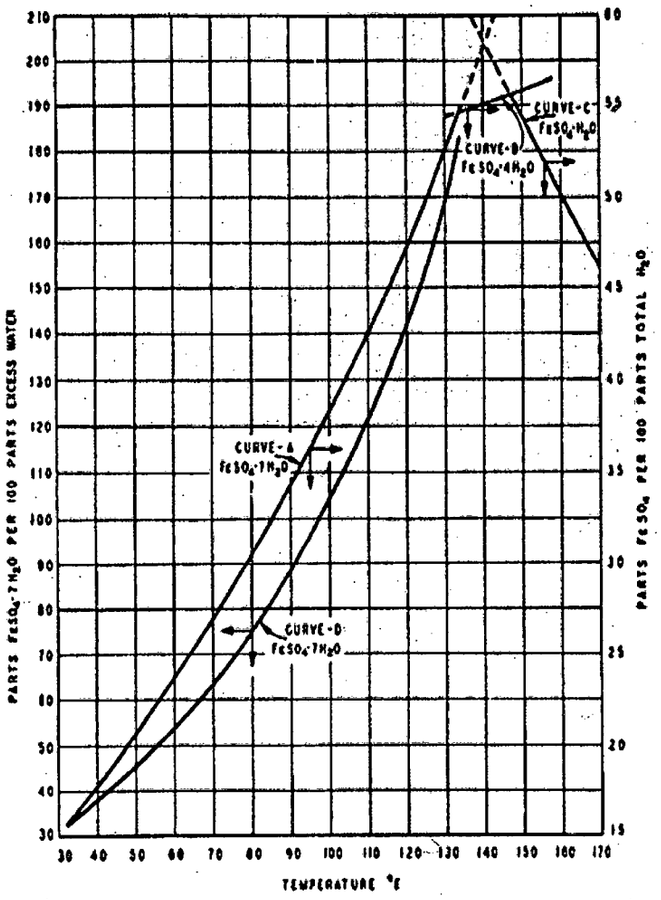
(i) The blade inlet angle
(ii) Exit velocity
(iii) The diagram efficiency

7. (a) Discuss the importance and types of equipment used in gas-solid separation. **(10)**

(b) Classify the gas cleaning fabric filters. What are the factors that affect the efficiency of fabric filters? **(30)**

8. (a) Discuss the working principle of major types of relief devices (with neat sketch). **(20)**

(b) Specify the location of reliefs in the simple polymerization reactor system shown in fig 8(b) and attach it with the answer script. What are the relief scenarios can be developed in each location? **(20)**



Solubility of ferrous sulfate. Curve A,B, and C as usually plotted; curve D plotted as parts hydrate per 100 parts excess water.

Figure for Question 1.(a)

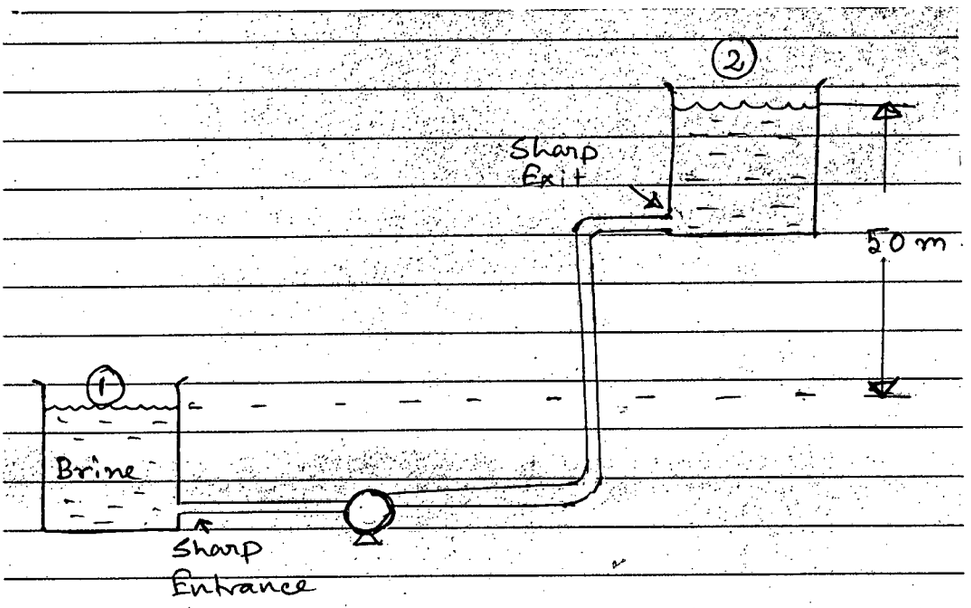


Figure for Question. 2 (a)

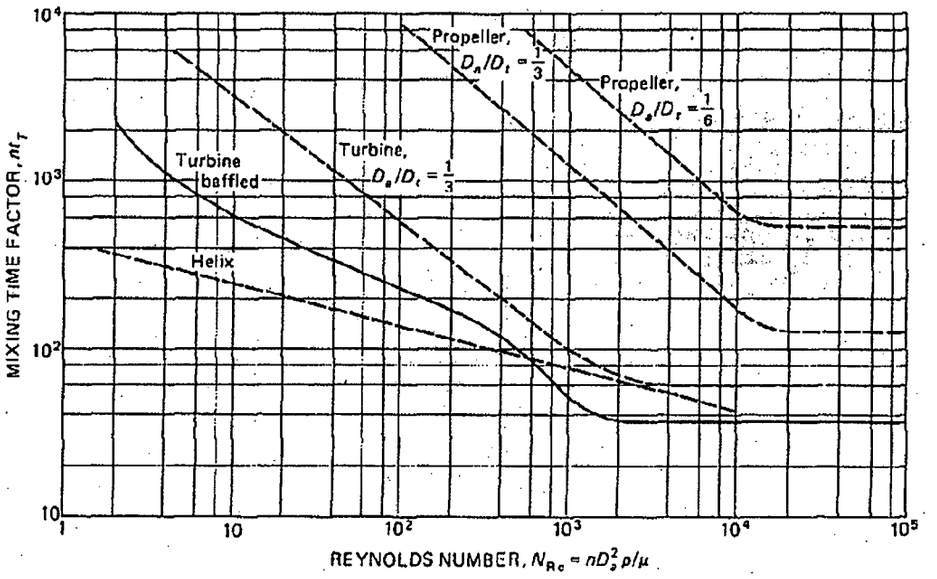
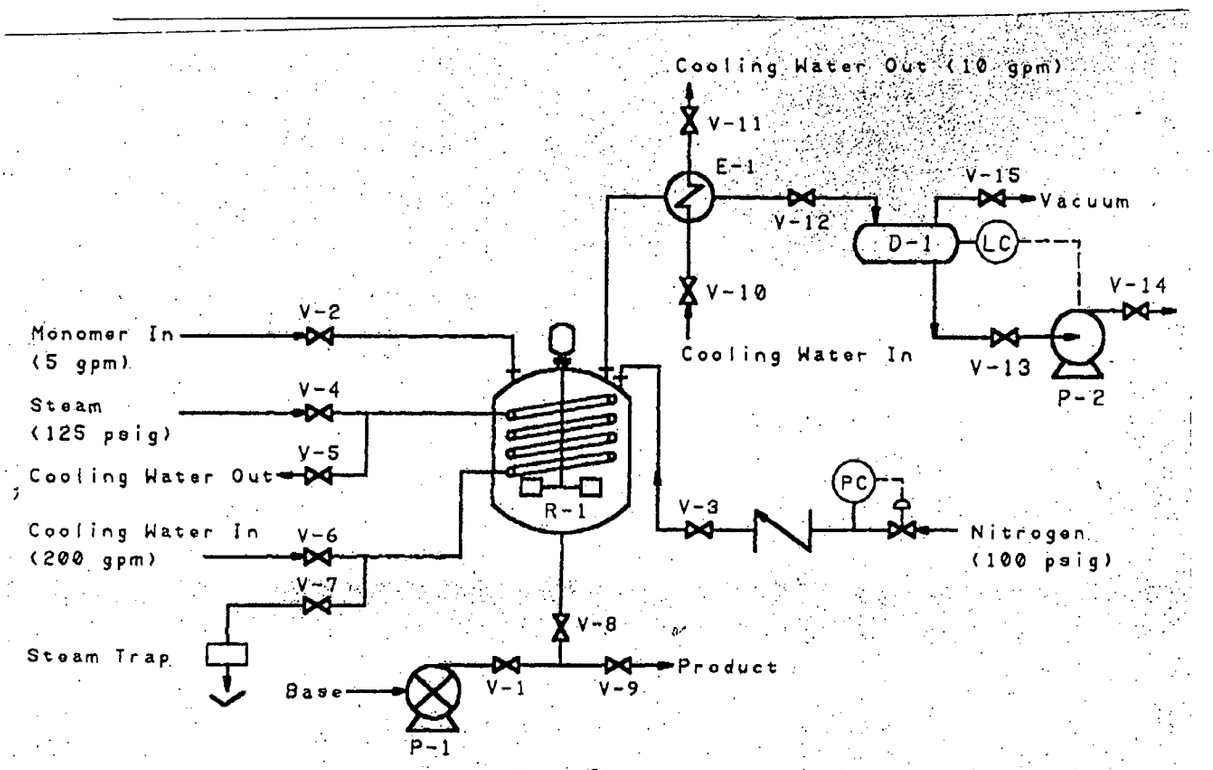


FIGURE 9.25
Mixing times in agitated vessels. Dashed lines are for unbaffled tanks; solid line is for an unbaffled tank.

Figure for Question 3.(a)



Specifications

Name	Description	Max. psig	Gpm at 50 psig
D-1	100 Gal Drum	50	—
R-1	1000 Gal Reactor	50	—
P-1	Gear Pump	100	100
P-2	Centrifugal Pump	50	20

Piping:	Size
Steam and Water Lines	2 inch
Nitrogen	1 inch
Vapor Lines	0.5 inch

Figure-8 (b): Polymerization Reactor (Attached this page with the answer script)

L-3/T-2/CHE **Date : 09/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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**.

1. (a) For the purpose of issuance of Environmental clearance Certificate, categorize the industrial units and projects. Write down the standards for discharge water quality for composite textile and tannery industries permitted by the ECR 1997. **(10)**

(b) Define the followings in context of wastewater characteristics: **(12)**

(i) Organic and inorganic pollutants

(ii) BOD and COD

(iii) TOC and DOC

(iv) p^H and alkalinity

(c) A BOD test was conducted on a domestic wastewater at 30°C. The Wastewater portion added to a BOD bottle was 20 mL and the dissolved oxygen values listed below were measured. **(13)**

Time (d)	DO (mg/L)
0	7.4
1	5.5
2	4.5
3	3.7
4	2.5
5	2.1

Calculate the value of BOD_3. Determine the BOD rate constant K_{30}. Calculate the value of BOD_5 at 20°C. Assume a reasonable value for any missing data.

2. (a) Define toxin, sludge bulking and SVI in activated sludge process. **(6)**

(b) Show different stages of anaerobic treatment of wastewater with a neat sketch. Describe each stage. **(12)**

(c) Mention the type of aerators used in the wastewater treatment. Why is nutrient removal important? Explain phosphorous removal mechanism in EBPR process. **(9+8)**

3. (a) Draw a block diagram of a typical wastewater treatment plant and label it properly. **(6)**

(b) "MLSS is a critical parameter of acerbic biological treatment". Explain why. **(6)**

Contd P/2

CHE 481

Contd... Q. No. 3

(c) Compare aerobic and anaerobic treatment processes. **(8)**

(d) Explain electrical double layer theory of coagulation with a neat sketch. **(8)**

(e) Explain Kjhadal nitrogen removal mechanism from wastewater. **(7)**

4. (a) Discuss the principle of self purification process of river. **(8)**

(b) What do you understand by oxygen sag curve? Derive the classical Streeter-Phelps oxygen sag curve equation. **(15)**

(c) A wastewater stream has a dissolved oxygen (DO) concentration of 1.5 mg/L, a flow rate of 0.5 m^3/s, a temperature of 26 °C and an ultimate BOD of 48 mg/L. **(12)**
The main stream water is running at 2.2 m^3/s at a saturated DO, a temperature of 12 °C and an ultimate BOD of 1.6 mg/L. If the wastewater stream is mixed with the main stream, calculate the dissolved oxygen concentration at 48.3 km downstream from the mixing point. Also determine the critical DO deficit (D_c) and critical time to reach D_c (t_c).
Given $K_1 = 0.2/d$ and $K_2 = 0.4/d$, where K_1 and K_2 have their usual meanings.

SECTION-B

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

5. (a) What are the criteria pollutants and Hazardous Air Pollutants as per USEPA? Why are they named so? List 3 health impacts of each of the criteria pollutants. **(6+9=15)**

(b) Briefly discuss the differences between 4 major types of particulate pollutants. **(8)**

(c) Write short notes on the followings: **(6×2=12)**

(i) Smog formation,

(ii) Isokinetic sampling.

6. (a) How does air pollution affect ozone layer? Briefly describe cycle and write down the reactions involved in catalytic cycle due to CFC. **(4+4+4=12)**

(b) How can you reduce air pollution through process modification? Discuss with some suitable examples. **(8)**

(c) For a gravity settler, derive $\eta_{mixed} = 1 - \exp(-\eta_{block\ flow})$. Symbols have their usual meanings. List the assumptions you make to derive this. Considering that the same approach is applicable for centrifugal separator, derive the equation of the removal efficiency for the block flow in terms of process parameters. **(10+5=15)**

7. (a) What are the possible approaches to remove SO_2 from the waste gases? Discuss with proper schematics. **(12)**

Contd P/3

CHE 481

Contd... Q. No. 7

(b) With help of a schematic show the major components of a typical high volume sampler. **(8)**

(c) During an ambient air pollution measurement, 25 ml solution of sodium hydroxide and sodium arsenite mixture was used to absorb ambient NO_2 for 12 hours. 10 ml of this sample was mixed with other reagents and 50 ml of colored solution was prepared for spectrophotometric analysis. Air flow rate was 0.5 m^3/min during the experiment. What would be the concentration of ambient NO_2 in $\mu g/ m^3$ if the absorbance reading was 0.89? Sampling efficiency can be assumed to be 82%. Following data were obtained to prepare a calibration curve for the particular analysis. **(15)**

Concentration of NA NO_2 salt $\mu g/ m^3$	Absorbance
0.1	0.09
0.25	0.21
0.5	0.41
0.9	0.72
1.2	0.92

8. (a) Classify the meteorological parameters which affect air pollution. **(7)**

(b) List the assumptions involved in Gaussian dispersion model. Draw a typical stack emission profile and label the major parameters of the Gaussian dispersion model. **(10)**

(c) Define different lapse rate. Explain the stable, unstable and neutral conditions in terms of lapse rate. **(12)**

(d) "Ozone is a summer pollutant"–explain. **(6)**

OXYGEN SOLUBILITY TABLE

a xylem brand

Solubility of Oxygen (mg/L) in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

Temp °C	Chlorinity 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

L-3/T-2/CHE **Date : 09/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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**.

1. (a) Briefly discuss the evolution of Biochemical Engineering as a new discipline. **(10)**

   (b) What are viruses? Explain different life cycles of viruses. **(10)**

   (c) Discuss Protein Structures. Briefly explain protein categories with appropriate examples. **(15)**

2. (a) What are Cell Nutrients? Write down the physiological function and required concentration of the major macronutrient elements. **(10)**

   (b) Briefly explain the structure and classification of Amino Acids as protein building blocks. **(13)**

   (c) What is Antibody? Briefly discuss antibody structure, their functions and biotechnological applications. **(12)**

3. (a) A textile dyeing industry runs a biological ETP to treat process wastewater. The biological ETP produces solid sludge as a by-product. As a technical consultant would you advise to produce compost fertilizer using the solid sludge? If yes, what are the critical factors to be considered to produce effective compost fertilizer using solid sludge? **(10)**

   (b) Draw a schematic diagram of an activated sludge process. using the Monod equation for microbial growth and material balance for biomass and substrate, derive an expression to calculate cells' (solids') residence time using volume of sludge tank, effluent flow rate, and the ratio of excess sludge flow to feed flow rate. **(15)**

   (c) Write down the major categories of Enzymes. Briefly explain Enzymatic Function based on Activation Energy and Molecular Aspects. **(4+6)**

4. (a) Explain pH and temperature effects on Enzyme Denaturation with appropriate equations and graphical representation. **(12)**

   (b) What is Enzyme Inhibition? Write down inhibited enzyme kinetic scheme and rate equation for the non-competitive Inhibitors with appropriate equations. **(8)**

Contd P/2

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Contd... Q. No. 4

(c) The hydrolysis of urea by urease shows inhibition. Data for the hydrolysis of the reaction are shown in the table. **(15)**

Inhibited Enzyme Kinetics are given below:

For Competitive inhibition:

$$v = \frac{V_m[S]}{K_m'\left[1+\frac{[I]}{K_I}\right]+[S]}$$

For Noncompetitive inhibition:

$$v = \frac{V_m}{\left[1+\frac{[I]}{K_I}\right]\left[1+\frac{K_m'}{[S]}\right]}$$

For Uncompetitive inhibition:

$$v = \frac{V_{m,app}[S]}{K_{m,app}'+[S]}$$

(i) Determine the Michelis-Menten constant (K'_m) for this reaction.

(ii) What type of inhibition reaction is this? Substantiate the answer.

(iii) Based on the answer to part b, what is the value of K_I?

Substrate Concentration: 0.2 M		Substrate Concentration: 0.02 M	
$1/v$	I	$1/v$	I
0.22	0	0.68	0
0.33	0.0012	1.02	0.0012
0.51	0.0027	1.50	0.0022
0.76	0.0044	1.83	0.0032
0.88	0.0061	2.04	0.0037
1.10	0.0080	2.72	0.0044
1.15	0.0093	3.46	0.0059

SECTION-B

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

5. (a) What are the features that distinguish a bioreactor from a chemical reactor? **(10)**

(b) Write the steps in proper order for the preparation of a fermentation process. **(10)**

(c) What is SSF? What is its importance? **(15)**

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6. (a) What is ELISA and what are the major applicants of ELISA? **(10)**

(b) Write down the steps of direct and indirect sandwich ELISA. **(15)**

(c) You want to determine the presence of chikungunya virus from the hemolymph (a kind of blood present in insects) of Aedes mosquito. However, it is known that dengue virus might also be present in the hemolymph. What type of ELISA shall you use in such case? **(10)**

7. (a) Based on the basis of nutrients and shelf-life, what are the classifications of food. **(10)**

(b) Describe the nitrogen cycle. **(20)**

(c) Write a short note on Pasteurization. **(5)**

8. (a) Which type of bio safety laboratory do you need to use to handle the following organisms: **(20)**

(i) Influenza [An airborne pathogen].

(ii) Amoeba proteus [A type of single celled organism].

(iii) Hepatitis C [A blood borne pathogen].

(iv) B. braunii [A type of common algae].

Describe your choice separately for each of the organisms with reasoning.

(b) Describe temperature and pressure cycles of an autoclave. **(15)**

L-3/T-2/CHE **Date : 05/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 309** (Particle 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 any **THREE**.

1. (a) What do you understand by efficiency and effectiveness of screening of particles. **(5)**

(b) Derive a formula for effectiveness of screening which includes only mass fraction terms (eg. x_F, x_P, x_R = mass fraction of desired-size-range material in feed, product and rejected fraction). What is the utility of this formula? **(12)**

(c) Crushed galena from a ball mill has the following screen analysis: **(18)**

Tyler Screen Mesh	Weight Fraction
-28+35	0.150
-35+48	0.200
-48+65	0.171
-65+100	0.134
-100+150	0.104
-150+200	0.080
-200	0.161

Write down the empirical relationship which is typically used to estimate fine particle size distribution. Plot the appropriate graph and complete the screen analysis by determining the size distribution in the -200 mesh cut.

2. (a) Given the Kozeny Carman equation, **(15)**

$$\frac{\Delta P g_c}{L} = \mu\left(\frac{180(1-\varepsilon)^2}{\varepsilon^3}\right)\frac{1}{D_p^2}v_s$$

Derive an expression for θ, the time necessary to pass ***any*** volume V of filtrate (for constant pressure filtration).

(b) Explain the following terms in context of bin design: **(10)**

Mass flow, Tunnel flow, Interlocking, Arching and Arch breaker.

(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)**

3. (a) Derive the expression for total mass of crystals in unit volume of liquid m_c. Prove that mass production rate of crystals C is 6 $a\rho_c(G\tau)^4 Qn_0$. **(10)**

Contd P/2

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Contd... Q. No. 3

(b) An MSMPR crystallizer produces 1 ton of product per hour having a predominant size of 35 mesh. The volume of crystals per unit volume of magma is 0.15. The temperature in the crystallizer is 120° F, and the retention time is 2.0 h. The densities of crystals and mother liquor are 105 and 82.5 lb/ft^3, respectively.

(i) Determine the volume of liquid in the crystallizer, the required growth rate G and the necessary nucleation rate B^0. **(10)**

(ii) Plot the cumulative screen analysis of the theoretical product. **(15)**

4. (a) The following data were collected in the laboratory on the filtration of $CaCO_3$ sludge through a plate-and-frame filter press. After assembling the press, the data were taken as follows. **(22)**

Mass of filtrate, lb	Time, min
0	0
5	0.2
10	0.42
15	0.65
20	0.75
25	1.0
30	1.3

Temperature	= 20° C
Area of filter surface	= 1.87 ft^2
Feed concentration	= 5% $CaCO_3$ in H_2O
Pressure at inlet	= 6 psig (constant)
Density of dry cake	= 100 lb/ft^3
Specific gravity of $CaCO_3$	= 2.93
Viscosity of the filtrate	= 1.1 cP.
Density of water at 20° C	= 62.4 lb/ft^3

Define V_e and α in context of filtration. Determine V_e and α for the above situation.

(b) Starting from the fundamental relationship for MSMPR, derive the differential distributions for number, size, area and mass. **(13)**

Contd P/3

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SECTION-B

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

5. (a) The equations giving the number distribution curve for a powdered material are $dn/dd = d$ for the size range 0 to 10 μm and $dn/dd = 100{,}000/d^4$ for the size range 10 to 100 μm. Sketch the number, surface and weight distribution curves. **(10+7+7=24)**

(b) For centrifugal classification, prove that, **(6)**

$$v_R = \frac{v_t}{g} \cdot \frac{v_{\tan}^2}{r}$$

Where symbols have their usual meanings.

(c) Write a short note on cycle efficiency. **(5)**

6. (a) A tubular bowl centrifuge is to be used to separate water from a fish oil. This centrifuge has a bowl 4 in. in diameter by 30 in. 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 in. and 1.250 in., respectively. **(12+5=17)**
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.

(b) With necessary diagrams, describe the working principles of 'Elutriator' and 'Double-cone classifier'. **(5+5=10)**

(c) This question is based on 'Classification'. Define separation ratio and prove that, separation of the particles based on terminal settling velocity is possible only if the separation ratio is greater than $\left(\frac{\rho_b - \rho}{\rho_a - \rho}\right)^n$. Here, symbols have their usual meanings. **(2+6=8)**

7. (a) A laboratory viscometer consists of a steel ball and uniform-diameter glass cylinder. The cylinder is filled with the test fluid, and the time for the ball to fall a known distance is recorded. The ball is 0.25 in. in diameter, and the index marks are 8 in. apart. The viscosity of corn syrup having a density of 1.3 g/cm^3 is desired. The measured time interval is 7.32 sec. What is the viscosity of the syrup? Specific gravity of the steel ball is 7.9. **(18)**

(b) What do you understand by Normal or Random Distribution? Give a real life example to elaborate your answer. Define Skewness and explain its relationship to the Normal Distribution. Why are we studying Normal Distribution in "Particle Technology"? **(17)**

Contd P/4

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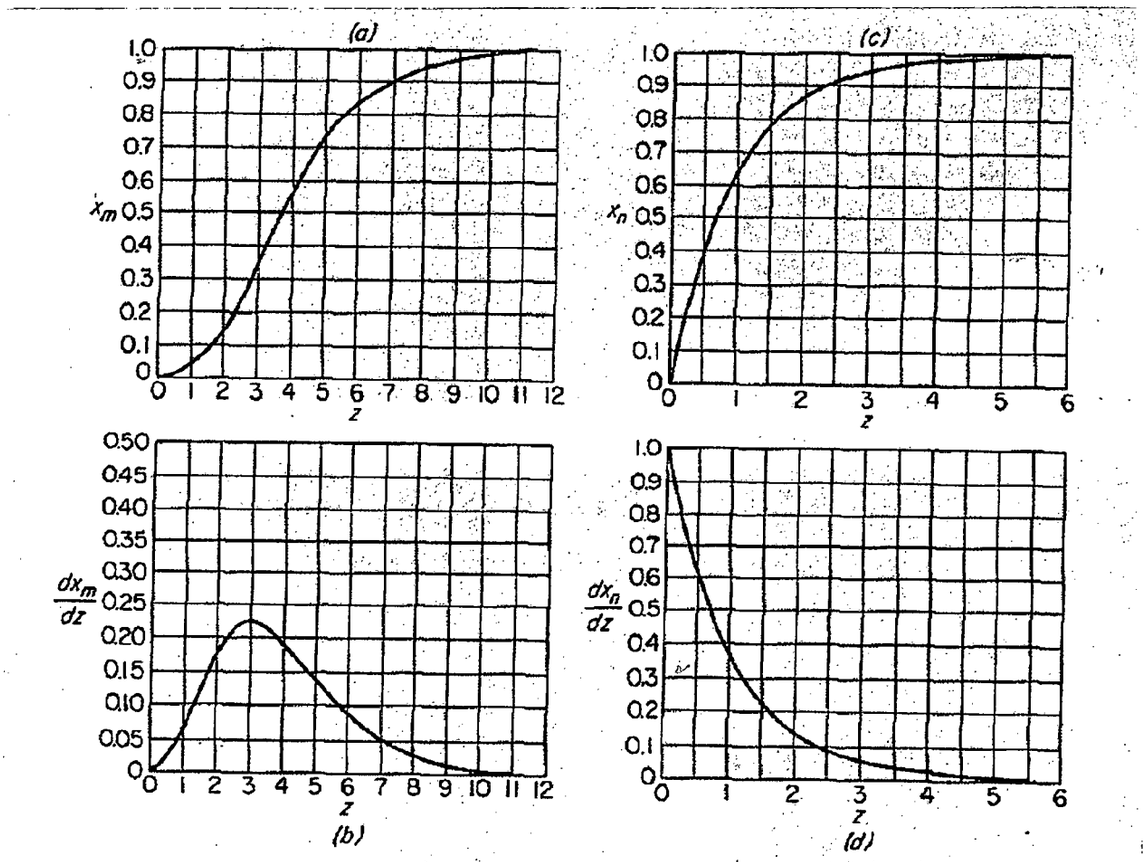
8. (a) A sand filter consists of uniform spherical particles of -20+28 mesh size. After back flushing with water, the sand bed has settled to a stable depth of 6 ft and is flooded with water to a depth of 3 ft above the top of the sand. If the drained valves are opened, how long will it take the bed to drain until the water level is even with the top of the bed? **(18)**

(b) Write down the steps with explanation of the derivation of Navier-Stokes Equation? Your answer should include – a sketch; the coordinate system; the starting equations and the steps in the derivation. You do NOT need to perform the full derivation. **(17)**

$$C_D = \frac{24}{N_{Rep}}, N_{Rep} > 1$$

$$C_D = \frac{24}{N_{Rep}}\left[1 + 0.14 N_{Rep}^{0.7}\right], 1 \le N_{Rep} \le 1000$$

$$C_D = 0.44, N_{Rep} > 1000$$



Figures for Question 3

Size-distribution relations in mixed suspension:

(a) cumulative mass distribution; (b) differential mass distribution; (c) cumulative population distribution; (d) differential population distribution.

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