L-3/T-2/CHE **Date : 18/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

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

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**.

Attach diagram with Answer scripts.

1. (a) Discuss briefly the different performance characteristics of reciprocating compressor. **(22)**

(b) For three stage compression, what should be pressure across the cylinder if the intercooler and piping pressure is 3 psi? Discharge from last stage is at 165 psia and suction to the first stage is at 0 psig. **(16)**

(c) How surge is controlled in centrifugal compressors? **($8\frac{2}{3}$)**

2. (a) Write a short note on any two of the following:- **(12×2=24)**

(i) Entrainment separator

(ii) Optimum operation time of Evaporator.

(iii) Effect at boiling point elevation on capacity of evaporators.

(b) With help of schematic diagram, discuss the working principle of backward feed multiple effect evaporator. **($10\frac{2}{3}$)**

(c) A triple effect evaporator is concentrating a liquid that has no appreciable elevation in boiling point. The temperature of the first effect is 108° C and boiling point of solution in the last effect is 52° C. The overall heat transfer coefficients in W/m^2C are 2500 in the first, 2000 in the second and 1500 in the third effect. At what temperatures will the liquid boil in the first and second effect? **(12)**

3. (a) Write down the steps of crystallization and discuss with the help of concentration vs temperature graph. **($6\frac{2}{3}$)**

(b) Prove that Power number is a function of Reynold's Number for mechanically agitated adequately baffled vessel. **(12)**

(c) Write different shape factors for turbine. **(6)**

(d) A flat blade turbine with six blades is installed centrally in a vertical tank. The tank is 6 ft in diameter, the turbine is 2 ft in diameter and is positioned at 2 ft from the bottom of the tank. The turbine blades are 5 in wide. The tank is filled to a depth of 6 ft with a solution of 50 percent caustic soda at 150° F, which has a viscosity of 12 cP and density of 93.5 lb/ ft^3. The turbine is operated at 90 r/min. The tank is baffled. What power will be required to operate the mixer? **(12)**

(e) Discuss the working principle of draft tube baffled vacuum crystallizer with the help of schematic diagram. **(10)**

Contd P/2

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4. (a) In a chemical industry you have been assigned to select an industrial dryer. Discuss the general guidelines for selecting such dryers. **(18)**
(b) It is necessary to pump a liquid with properties similar to water at a rate of 300 gal/min against a head of 70 ft. Recommend a pump type and size. Make necessary assumptions. **(12)**
(c) Write the advantages of spray drying. **(10)**
(d) "An increase in steam pressure over design will not increase vapor handling capacity for a fixed capacity ejector – why? Explain. **($6\frac{2}{3}$)**

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE** questions.
Number of extra item/s included in this manuscript in the form of chart, table, etc. (one).

5. (a) Use the sylvan chart supplied to select mechanical separation equipment for the following.
(i) Material leaving a chemical process varies between 20 and 40 grains/ cu. ft. with 60 to 80 micron range of mass mean diameter of particles. A low resistance cyclone followed by a high efficiency by a high efficiency cyclone would be used. What will be the final concentration and mean particle size of the gaseous stream? **($9\frac{2}{3}$)**
(ii) Flue gas leaving a kiln chimney has a particle concentration of 50 grains/ cu. ft and a mean size of 8 microns. What is the cheapest equipment that can be used to achieve 70% collection efficiency? What equipment can be used to achieve 98% collection efficiency? **($5\frac{1}{2}+5\frac{1}{2}$)**
(b)
(i) How does electrostatic precipitator work? –Explain with a neat sketch. **(7)**
(ii) Propose mechanical separator configurations suitable for particle separation from gaseous emission in cement manufacturing industry and coal fired power plant. Why do you propose such configurations for these industries? –Explain. **(6)**
(c) With P-V diagram explain the basic working principles of two types of turbines used in industry. **(13)**

6. (a) How is the applied energy utilized in size reduction operation? State briefly. **(6)**
(b) A certain crusher accepts a rock feed having a volume-surface mean diameter of 19 mm and discharges a product of volume-surface mean diameter of 5 mm. The power required to crush 3 kg/s is 7 kW. What should be the power consumption if the capacity of the crusher is reduced to 2.5 kg/s and the volume-surface mean diameter to 3.5 mm? Assume that the mechanical efficiency of the crusher remains constant. **(16)**

Contd P/3

CHE 311

Contd... Q. No. 4

(c) What is the speed beyond which grinding action in a ball mill is negligible? Establish the mathematical relationship of that speed and hence comment on the variable parameters of the relationship. **(12)**

(d)

(i) What is the separation principle of a plate type zig-zag impingement separator?- Explain briefly with a neat sketch. **($6\frac{2}{3}$)**

(ii) What are the major limitations of a normal belt conveyor? How can you overcome these limitations in case of a normal belt conveyor? **(6)**

7. (a) What will be your inspection criteria for final acceptance of rupture disc?- Explain. **(10)**

(b) Balance safety valve is advantages to offset back-pressure effect." – Justify the statement with some mathematical proof. **(14)**

(c) What are the requirements for installing pressure relieving devices as per codes such as ASME section VIII, Div. 1 or 2? **(8)**

(d) How does a fabric filter separate particulate for gaseous emission? – Explain. **($9\frac{2}{3}$)**

(e) Explain 'Set pressure' and 'operating pressure' of a non-fired and a fired vessel. **(5)**

8. (a) What are the factors that influence the selection of a steam turbine. **(12)**

(b) How can you convert a belt conveyor into a vertical elevator?- Explain with a schematic diagram. **(7)**

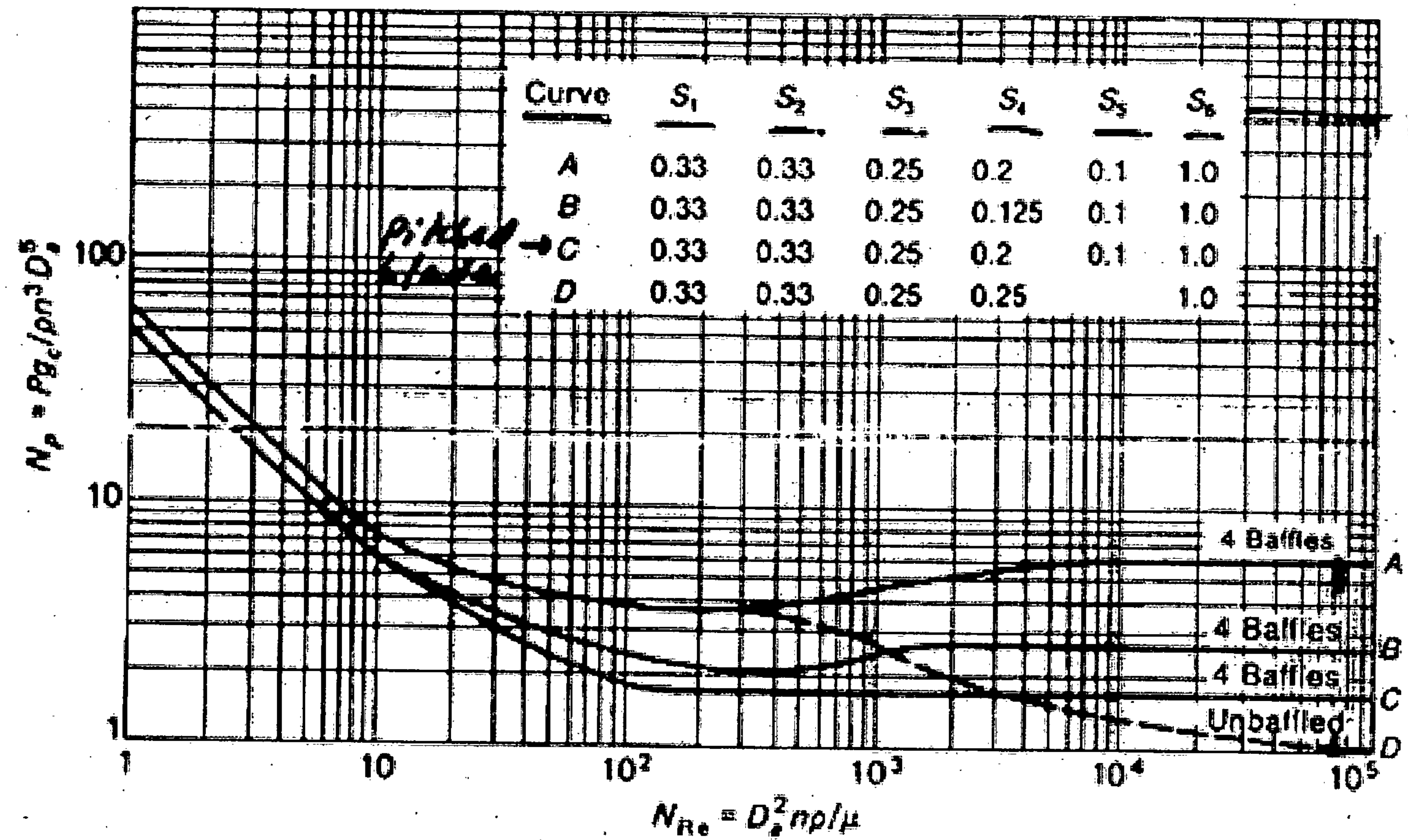
(c) What will be the specification of a screw used for conveying free flowing materials? A screw used for conveying free flowing materials? A screw conveyor has the following specification: **(5+8)**

Screw dia: 1 foot; shaft dia: 0.5 foot; Screw pitch: 1 foot; Trough loading: 50%; the screw rotates at a speed of 30 rpm. Determine the capacity of the screw conveyor.

(d) What types of the pressure relieving devices are used for low-pressure storage tank in refinery? – Show their working mechanism with diagram. **($14\frac{2}{3}$)**

ATTACH THIS SHEET WITH YOUR ANSWER SCRIPTS

Q 3(d)



FIGURE

Power number N_p versus N_{Re} for six-blade turbines. (*After Chudacek*[11]; *Oldshue.*[35]) With the dashed portion of curve *D*, the value of N_p read from the figure must be multiplied by N_{Fr}^m.

Q 4(d)

ATTACH THIS SHEET WITH YOUR ANSWER SCRIPTS

Table 21.1 PUMP CHARACTERISTICS

	Centrifugal: Standard (Radial Flow)	Centrifugal: Turbine (Mixed Flow)	Centrifugal: Propeller (Axial Flow)	Rotary (Gear or Screw)	Reciprocating (Piston or Plunger)
Head (or discharge pressure)	High, single stage — up to 600 ft; multistage — up to 6000 psi	Intermediate, up to 200 ft	Low, up to 60 ft	Intermediate up to 600 psi	Highest available up to 100,000 psi
Capacity (or delivered flow rate)	Low (100 gal/min) to very high (200,000 gal/min)	Intermediate, up to 16,000 gal/min	High, up to 100,000 gal/min	Low (1 gal/min) to intermediate (500 gal/min)	Intermediate up to 500 gal/min
Liquids handled	Clean or dirty	High solids contents	Abrasive	Up to high viscosity; nonabrasive	Clean; no solids
Metering or flow-control capability	No	No	No	Yes	Yes

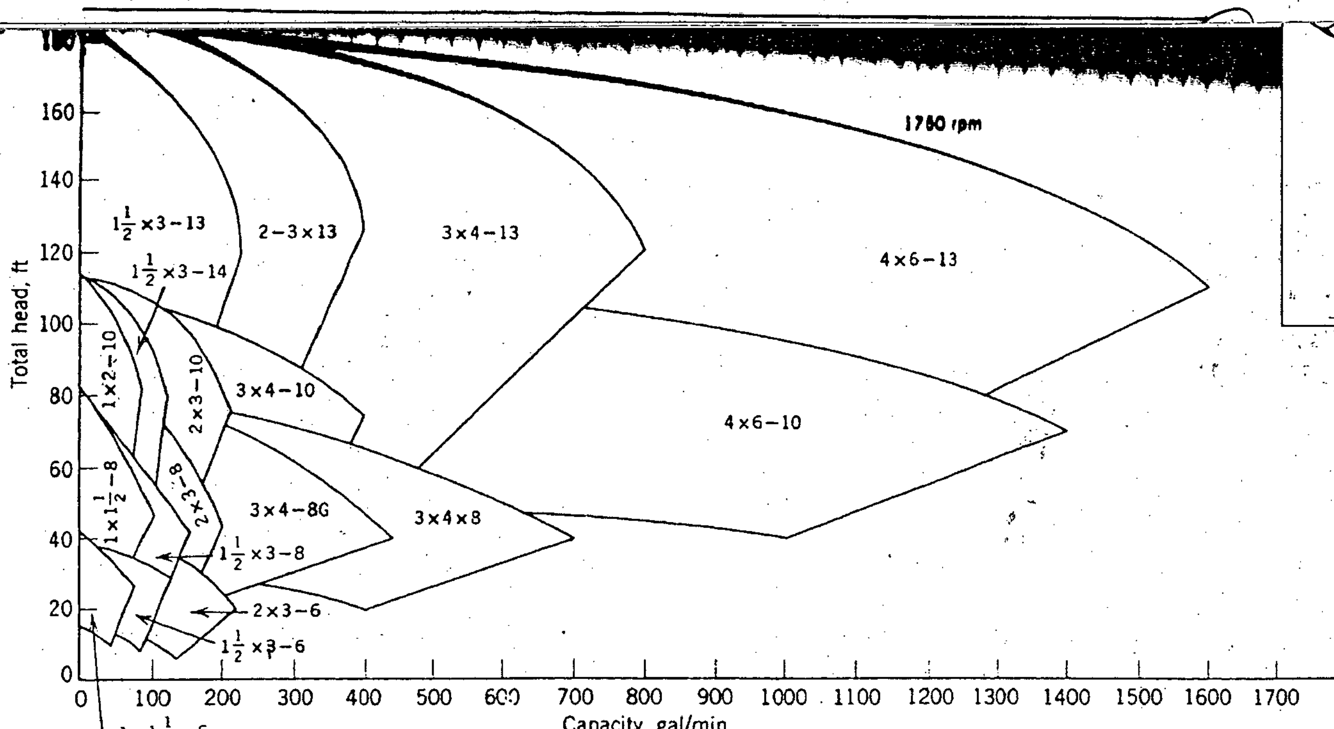


Figure 21.23. Operating ranges of a series of centrifugal pumps. Each labeled area represents the head/capacity region in which a specific size pump can operate. The model number is given for each size, where the first number is the diameter of the discharge line, the second is the diameter of the suction line, and the third is the maximum diameter of impeller that will fit in the pump casing. All diameters are in inches. Figure 21.17a gives detailed operating characteristics of one size pump in this series. This pump's range overlaps the ranges of several smaller-size pumps in this series, as can be seen by comparing the figures. (Courtesy Goulds Pumps, Inc.)

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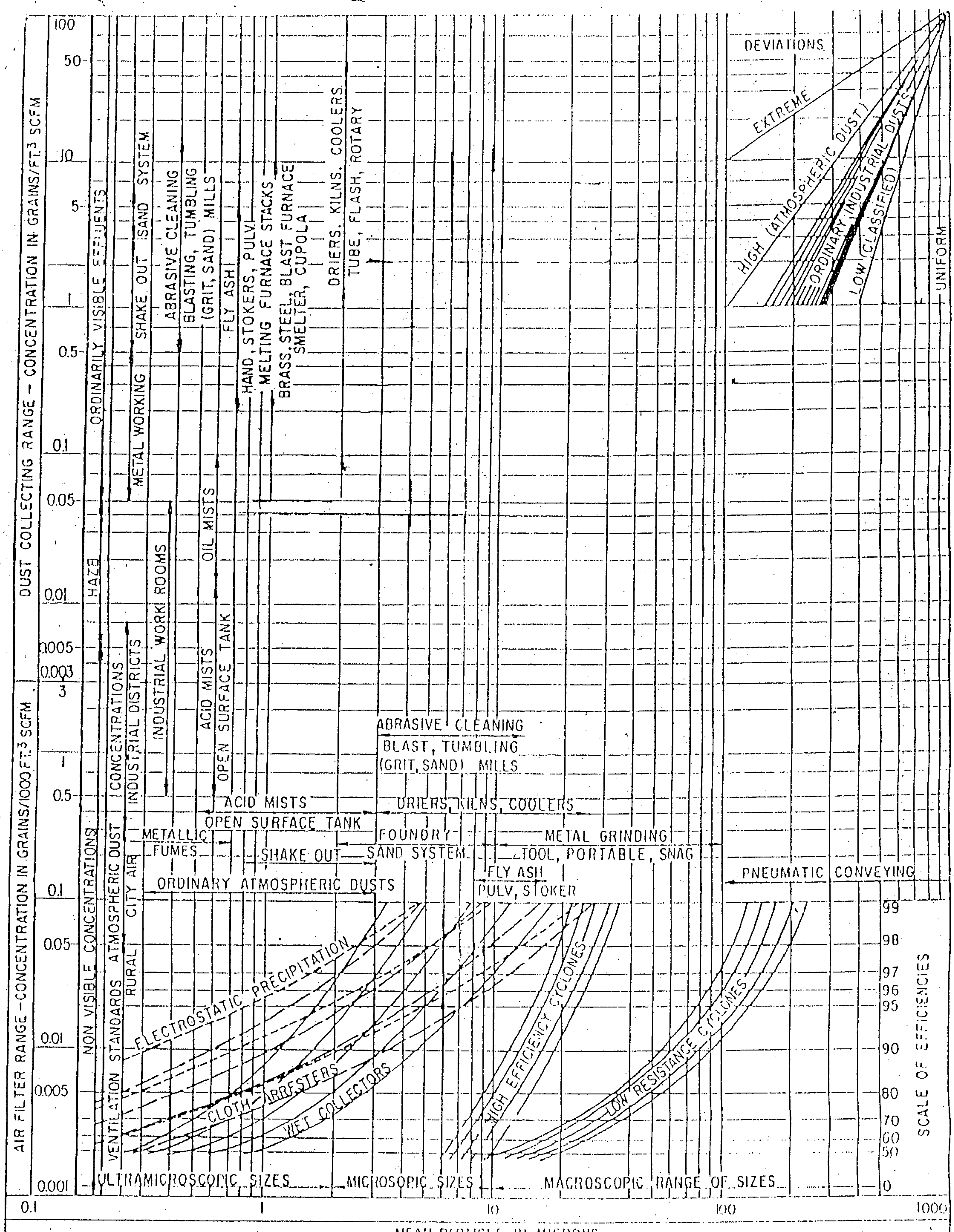

Qs.5(a)

= . a a(A)

L-3/T-2/CHE **Date : 24/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

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** questions.

1. (a) Describe the different mechanisms of mass transfer across porous and non porous membranes in case of gas separation. **(15)**

(b) Calculate the membrane area required for the single stage RO desalination system given below: **(20)**

Water permeability is 2.05×10^{-6} $m^3/(m^2\ s\ kPa)$

Salt permeability is 2.03×10^{-5} $m^3/(m^2\ s\ kPa)$

Feed salinity is 42,000 ppm, Feed flow rate: 2.5 kg/s; Permeate flow rate: 1 kg/s

Average feed side pressure: 8000 kPa; Permeate pressure: 101 kPa.

2. (a) "Regeneration of adsorbent often is achieved by an increase in temperature"-explain with the help of adsorption isotherms. **(10)**

(b) A waste stream of alcohol vapor in air from a process was absorbed by activated carbon particles in a packed bed having a diameter of 4 cm and length of 14 cm containing 79.2 g of carbon. The inlet gas stream having a concentration C_o of 600 ppm and a density of 0.00115 g/cm^3 enter the bed at a flow rate of 754 cm^3/s. The concentrations of the breakthrough curve are given in Table for Q. No 2(b). Set the breaking concentration at 0.1 of C_o. Calculate the (i) breaking time t_b; (ii) length of the unused bed and (iii) saturation loading capacity of the carbon. **(25)**

Table for Q. No. 2(b)

Time (h)	0	3	3.5	4	4.5	5
C/C_o	0	0	0.002	0.03	0.155	0.396
Time (h)	5.5	6	6.2	6.5	6.8	
C/C_o	0.658	0.903	0.933	0.975	0.993	

3. (a) Explain the following terms in relation to cooling tower operation: **(15)**

(i) drift, (ii) make-up (iii) approach

(b) A cooling tower is to cool 20000 lb/h of water from 120 °F to 80 °F. Inlet air will have a dry bulb temperature of 60 °F and a wet bulb temperature of 50 °F (h = 20.3 Btu/lb). A height of transfer unit 10 ft is expected.

Mass flux of air is 800 lb/(hr-ft^2). Cross sectional area of the tower is 20 ft^2. Estimate the height of the tower. Enthalpies of saturated air-water vapor mixtures are given in the table for Q. N. 3 (b). **(20)**

Contd P/2

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Contd... Q. No. 3(b)

Table for Q. No. 3 (b)

Temp, t °F	H*/(Btu/lb)
80	43.7
85	49
90	56
95	63.3
100	72
105	81.3
110	92.3
115	105
120	119.3

4. (a) Write short notes on the following: **(5×7=35)**
   (i) Irreversible adsorption
   (ii) Langmuir isotherm
   (iii) Asymmetric membrane
   (iv) Membrane selectivity
   (v) Analogy among heat, mass and momentum transfer.

SECTION-B

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

5. (a) Write a short notes on Relative vitality. **(5)**
   (b) A distillation column with total condenser and partial reboiler is used to separate methanol -water mixture. The feed rate is 152 kg moles/hr with composition of 40 mol% methanol. The feed is mixture of 60% liquid and 40% vapor by mole and is fed on the optimum plate which is N_F = 10. The distillate composition is 0.92 and bottom is 0.08 mole fraction of methanol.
   The optimum feed stage at total reflux, $N_{F,min} = 4$ **(30)**
   Find:
   (i) Relative volatility of the mixture.
   (ii) Minimum Reflux Ratio.
   (iii) External Reflux Ratio.
   (iv) Number of stages at total reflux.
   Given: The Gilliland correlation

$$\frac{N - N_{\min}}{N+1} = 1.0 - 18.571x$$

$$Where, x = \frac{L/D - \left(\frac{L}{D}\right)_{\min}}{1 + \frac{L}{D}}$$

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6. (a) An absorption column is used to absorb ammonia from air by using pure water as solvent. Calculate the percentage changes of absorption rate if the total pressure is changed from 100 to 200 kN/m^2 in the following cases: **(17)**

    (i) The feed stream contains 10% ammonia. Assume that all the resistance to mass transfer lies within the gas phase.

    (ii) Same as above but the absorbing solution exerts a partial vapor pressure of ammonia of 5 kN/m^2.

    [The diffusivity can be assumed to be inversely proportional to the absolute pressure]

    (b) Solute A is being absorbed from a gas mixture of A and B in a wetted-column tower. At a certain point in the tower the bulk concentrations are $Y_{AG} = 0.38$ and $X_{AL} = 0.10$. Solute A diffuses through stagnant B in the gas phase and then through a non-diffusing liquid. The film mass transfer coefficients for A are $K_y = 1.465 \times 10^{-3}$ kgmol A/s.m^2.molfr. and $K_x = 1.967 \times 10^{-3}$ kgmol A/s.m^2.molfr. Calculate the interface concentration and mass flux of A. **(18)**

    The equilibrium data is:

X_A	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35
Y_A	0	0.022	0.052	0.087	0.131	0.187	0.265	0.385

7. (a) An open bowl of 0.3 m diameter contains water at 350 K evaporating into the atmosphere. If the air currents are sufficiently strong to remove the water vapor as it is formed and if the resistance to its mass transfer in air is equivalent to that of a 1 mm layer for conditions of molecular diffusion, what will be the rate of cooling in KW due to evaporation? Diffusivity of water vapor in air may be taken as 0.2 cm^2/s. **(20)**

    Given that:

    Vapor pressure of water at 350 K = 41.8 KN/ m^2

    Latent heat of vaporization = 2318 KJ/kg.

    (b) A liquid containing small amount of suspended solid particles is fed at a high rate into a large dia distillation column. What type of column is to be used and why? **(5)**

    (c) Explain different types of packings. **(10)**

8. (a) A distillation column has only an enriching section with 5ft. of packing. A saturated vapor containing 23.5 mole% water and remainder acetone is fed into the column at a rate of 10 kmoles/hr. An L/V of 0.8 is required. Acetone is the more volatile component and the relative volatility of acetone-water system is 2.5. Acetone concentrations in the top vapor and bottoms liquid are 0.914 and 0.086, respectively. **(20)**

    (i) Find HETP of the column.

    (ii) Suppose you try to operate the column with 3.0 ft of packings (same HETP). What will happen?

    (b) Briefly explain the mass transfer theories that you have learned. Write their limitations. **(15)**

L-3/T-2/CHE **Date : 28/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

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** questions.

1. (a) What are the different processes available for pulping? According to you, what is the most versatile pulping process? Describe the process using a block diagram. **(3+2+15=20)**

   (b) What is the function of a "Hydrapulper"? **(4)**

   (c) Describe the qualities of chemical pulp to distinguish from mechanical pulp. **(6)**

   (d) What are the implications of high pulp viscosity? **(5)**

2. (a) If excess black liquor is available at a pulp mill, how are you going to utilize this? Describe the utilization process in brief. **(2+6=8)**

   (b) Describe the cooking liquor regeneration (Causticizing process) process using a block diagram. What are the most critical factors for this process? **(16+4=20)**

   (c) What is pulp consistency? Why is it important to maintain a certain pulp consistency in different stages of paper making process? **(3+4=7)**

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 3a (attached). **(3+2+5=10)**

   (b) What is the most critical issue with operating a recovery boiler? How can it be mitigated? **(3+4=7)**

   (c) What are the major steps of paper making process from pulp? Describe using a block diagram. **(3+12=15)**

   (d) What is the function of fillers for paper as finished product? **(3)**

4. (a) A recovery boiler shall deliver 300 MW of useful heat. The fuel (black liquor) analysis is as follows:

   C = 30.7 wt%, H = 3.7 wt%, S = 5.7 wt%, O = 35.9 wt%, N = 0.07 wt%, and Ash = 23.93 wt%.

   The heating value of the fuel is 12.9 MJ/kg (reference temperature 25 °C). The gas temperature after the last exchanger is chosen to be 130 °C. Air comes at 30 °C and the fuel enters the boiler at 120 °C.

   On the basis of previous experience the following design data have been selected:

   Air equivalence ratio, λ – 1.25

Contd P/2

CHE 441

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

Combustion efficiency – 100%

Heat losses to surroundings – 1.5% of fuel energy

Solid residue – 20 % of fuel flow

Temperature of solid residue – 300 °C

C_p for solid residue – 1.2 kJ/kg K

C_r for fuel – 3.1 kJ/kg K

For air and flue (exit) gas, use 29×10^{-3} kJ/mol K and 28.6×10^{-3} kJ/mol K as the average C_p values respectively. **(15+7=22)**

(i) Calculate the required fuel, air flow and flow of combustion gases.

(ii) Calculate the rate of energy lost from the system with hot combustion (flue) gas.

(b) For liquid efficient treatment for a pulp and paper mill, what are different stages of treatment? What is the main purpose of last stage of the treatment? **(3+4=7)**

(c) What are the main pollutants resulting from pulp bleaching process? How can you minimize their release? **(3+3=6)**

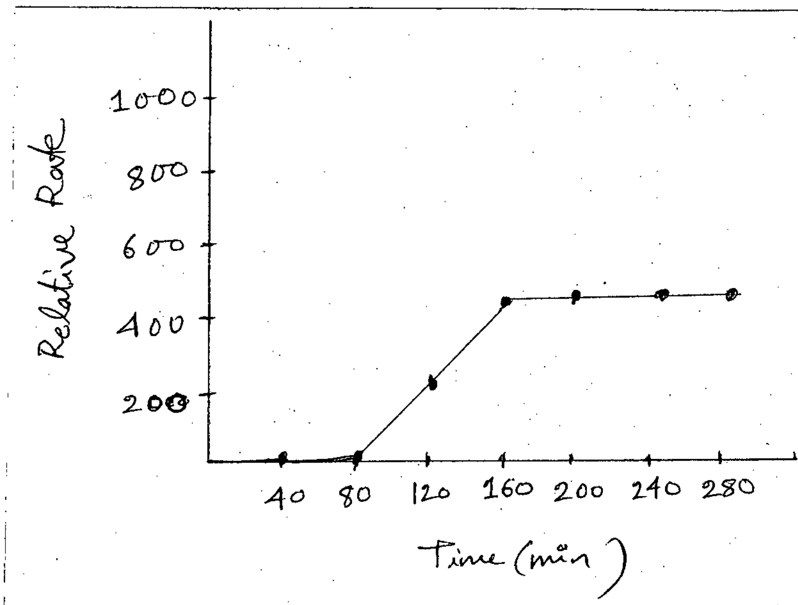

Figure 3a

SECTION-B

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

5. (a) Write a short note on "impact of fertilizers on human beings". **(7)**

(b) What is liquid fertilizer? Give comparison between liquid and solid fertilizer. **(7)**

(c) Justify the reason of applying mineral fertilizers in soil instead of applying organic fertilizers? Give comparison between organic and mineral fertilizers. **(7)**

Contd P/3

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Contd... Q. No. 5

(d) Phosphate rock itself contains P as a nutrient source. Explain why phosphatic fertilizers are applied in soil instead of applying phosphate rock. **(7)**

(e) Explain why two shift converters are used to convert CO to CO_2 in ammonia production process. **(7)**

6. (a) Write a short note on Ammonia-Urea industries in Bangladesh **(10)**

(b) What considerations should be accounted for designing a primary reformer? Give a neat sketch of primary reformer that used in Halder-Topsoe ammonia production process. **(12)**

(c) Describe briefly the distinguishing features of ammonia synthesis reactors. Point out the factors affecting ammonia synthesis reaction. **(13)**

7. (a) What are the environmental, safety and health consideration of ammonia storage, handling and transport? **(11)**

(b) What are the important features of the hydrogen recovery process during ammonia synthesis? **(6)**

(c) Write down the reactions that take place after applying urea in soil. **(6)**

(d) Describe the Stamicarbon urea manufacturing process with a block diagram. **(12)**

8. (a) Describe any urea granulation process in detail along with a neat sketch. **(12)**

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

(c) Write a short note on potash fertilizer manufacturing process. **(7)**

(d) Explain the terms: complex fertilizers and mixed fertilizers. Point out their distinguishing features. **(8)**

L-3/T-2/CHE Date : 28/02/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

Sub : **CHE 433** (Polymers and 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** questions.

1. (a) Explain configuration and conformation based on texture of polymers. **(10)**

   (b) Write distinguishing features of chain and step polymerization mechanism. **(10)**

   (c) Describe the kinetics and statistics of linear stepwise polymerization. **(15)**

2. (a) Derive the relationship for number-distribution function for a linear stepwise polymerization at extent of reaction P. **(9)**

   (b) Explain the different steps for polymerization of Ethylene to polythene. **(12)**

   (c) For conversion of monomer to polymer, deduce the following relationship describing different steps of initiation, propagation and termination: **(14)**

$$[M\cdot]=\left(\frac{fk_d[I]}{k_t}\right)^{1/2}$$

3. (a) Explain the term thermoplasts, thermosets and ealstomers. **(15)**

   (b) With net sketches, describe the five basic processes to form polymer products or parts. **(20)**

4. (a) Write a comparison of polymer processing techniques. **(8)**

   (b) What are crystallization, melting and glass transitions? **(12)**

   (c) Write short notes on: **(15)**

   (i) Polypropylene (PP)

   (ii) Rayon

   (iii) Polyester

SECTION-B

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

5. (a) Explain briefly the commonly accepted theory and history of crude oil formation. **(8)**

   (b) What are the fundamental factors for classifying crude oils? List and define all the commercially available crude oils of various classes. **(4+5)**

Contd P/2

CHE 433

Contd... Q. No. 5

(c) With the help of appropriate roadmap, elaborate the importance of crude oil in the context of polymers and petrochemicals. **(8)**

(d) Describe shortly the findings of the studies of structural geology, sedimentary basis analysis and reservoir characterization. **(10)**

6. In the context of refining and processing natural gas and crude oil, discuss the principle, importance and limitation of the following processes: **(5×7=35)**
   (i) Hydro cracking
   (ii) Merox Process
   (iii) Molecular Sieves
   (iv) Amine Gas Treating Process
   (v) Reforming Process.

7. (a) Almost all petrochemicals are derived from three sources – elaborate the statement. **(9)**
   (b) Discuss the significance of ethylene as the feedstock for petrochemicals. **(13)**
   (c) Benzene, toluene and xylenes, BTX are important precursors for plastics – explain with examples. **(13)**

8. (a) Write a technical note on the production of aniline from benzene via nitrobenzene. **(10)**
   (b) Discuss the commercial application and importance of the following petrochemicals: **(3×6=18)**
   (i) Methanol
   (ii) Detergent
   (iii) Waxes.
   (c) What conclusions can be drawn from characterization factor (KW) and correlation index (CI) regarding the chParacteristics of crude oil? **(7)**

L-3/T-2/CHE **Date : 06/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

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** questions.

1. (a) The following equations can be derived from the Carman Kozeny Equation:

$$\frac{1}{A}\frac{dV}{d\theta}=\frac{(-\Delta P_t)g_c}{\mu\frac{\alpha wV}{A}} \quad (A)$$

$$\frac{1}{A}\frac{dV}{d\theta}=\frac{(-\Delta P_t)g_c}{\mu rL} \quad (B)$$

(i) Both α and r are defined as specific cake resistance and are considered to be constant for incompressible cakes. State the formulae for α and write down its dimensions. **(5)**

(ii) Derive equation (B) from Carman Kozeny Equation, clearly showing the various steps and derive a formula for r during your derivation. Write down the dimensions for r. **(16)**

(iii) How are calculations for filtration equipment modified when the cakes are compressible? **(6)**

(b) "Sphericity has no effect on porosity" Do you agree? Why or why not? (You may include a sketch/plot/graph to illustrate your answer) **(8)**

2. (a) Explain the following terms in context of bin design (Use diagrams and/or formulae where applicable): α_r, α_m, μ, K′. **(8)**

(b) In a crystallizer 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 rates. **(18)**

Mesh Size	Cumulative percent retained (%)	Population density at crystal size, n (10^3/mmL)
14	3	18.87
20	16	211.02
28	40	1221.75
35	63	3661.40
48	83	94788.88
65	93	17647.09

(c) Give the suitable filtration equipment for following situations, giving the reasons for you answer? **(3×3=9)**

(i) Removal of dust particles from air

(ii) High filtration rates are required but filtration floor space is limited

(iii) Batch filtration is desired but manual labor is cost intensive

Contd P/2

CHE 309

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 $6a\rho_c(G\tau)^4Qn_o$. **(10)**

(b) Trisodium phosphate is to be recovered as $Na_3PO_4.12H_2O$ from a 35 weight percent solution originally at 90°C by cooling and seeding in a Swenson-Walker crystallizer. From 10,000 kg/h of feed, 3500 kg/h of product crystals are to be obtained. Seed crystals are fed at a rate of 250 kg/h and have the following size range: **(25)**

Weight fraction, percent	Size range, mm
10	-0.589+0.417
20	-0.417+0.295
40	-0.295+0.208
30	-0.208+0.147

Estimate the product particle-size distribution. Draw the corresponding graphs for product and seed crystal distribution.

4. (a) A slurry, at 20°C, containing 0.2 kg of solid per kilogram of water, is fed to a rotary drum filter 0.6 m long and 0.6 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 void age of 0.5, what thickness of cake is produced when filtering with a pressure difference of 65 kN/m^2? Calculate the specific resistance of the cake. The density of the solids is 3000 kg/m^3. **(25)**
Assume at 20°C, viscosity of the filtrate is 1.1 cP. and density of water is 1000 kg/m^3.

(b) Show that the ratio of specific surfaces (η) and the sphericity (ψ) may be related by the following equation. **(10)**

$$\eta = \frac{D_p}{D_0} \times \frac{1}{\psi}$$

SECTION-B

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

5. A single batch settling test was made on limestone slurry. The interface between clear liquid and suspended solids was observed as a function of time, and the results are tabulated below. The test was made using 236 gm of solid particle per liter of slurry. **(35)**

Time, hr	Height of interface, cm
0.00	36.0
0.25	32.4
0.50	28.6
1.00	21.0
1.75	14.7
3.00	12.3
4.75	11.6
8.00	10.0
12.00	9.8
20.00	8.8

CHE 309

Contd... Q. No. 5

Feed rate of the slurry is 3.785×10^6 L/day. The underflow velocity is to be 500 cm/day. Calculate the total flux for the thickener and represent the relation of total flux with concentration graphically. Determine Solid Handling Capacity (SHC) of the thickener from the graph. Draw the operating line for SHC and determine the maximum underflow concentration (C_u). Also calculate the length of the square shape thickener. Data for batch flux is given below.

Time, hr	Batch flux, g/cm^2.hr
0.5	15.71
1.0	17.30
1.5	17.90
1.8	15.00
2.0	11.80
2.20	9.00
2.50	5.00
2.70	2.00
3	0.67
4	0.39
5	0.37
6.5	0.28
8	0.11

6. (a) With a neat and clean schematic diagram of a cyclone separator show the significant design dimensions. **(7)**

(b) The following table gives the size distribution of a dust as measured by microscope. Convert these figures to obtain the distribution on a weight basis and calculate specific surface, assuming spherical particles of SG 2.65. **(28)**

Size range in μm	Number of particles in range
0-2	2000
2-4	600
4-8	140
8-12	40
12-16	15
16-20	5
20-24	2

7. (a) A packed bed of solid particles of density 2500 kg/m^3, occupies a depth of 1 m in a vessel of cross-sectional area 0.04m^2. The mass of solids in the bed is 50 kg and the surface-volume mean diameter of the particles is 1 mm. A liquid of density 800 kg/m^3 and viscosity 0.002 Pas flows upwards through the bed. **(20)**

Contd P/4

CHE 309

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

(i) Calculate the voidage (volume fraction occupied by voids) of the bed

(i) Calculate the pressure drop across the bed when the volume flow rate of liquid is 1.44 m^3/h.

(iii) Calculate the pressure drop across the bed when it becomes fluidized.

(b) Define the following terms – Super Colloids Lyophilic, Sol and Peptizing. Discuss the mechanism of Coagulation and Flocculation. Give one practicle application of each. **(15)**

8. (a) 50 kg of 500 μm Copper particles (ρ_p = 8.8 gm/cc) is fluidized using water at ordinary conditions in a column of diameter 20 cm. What is the bed height when the velocity is 4.2 cm/s. **(15)**

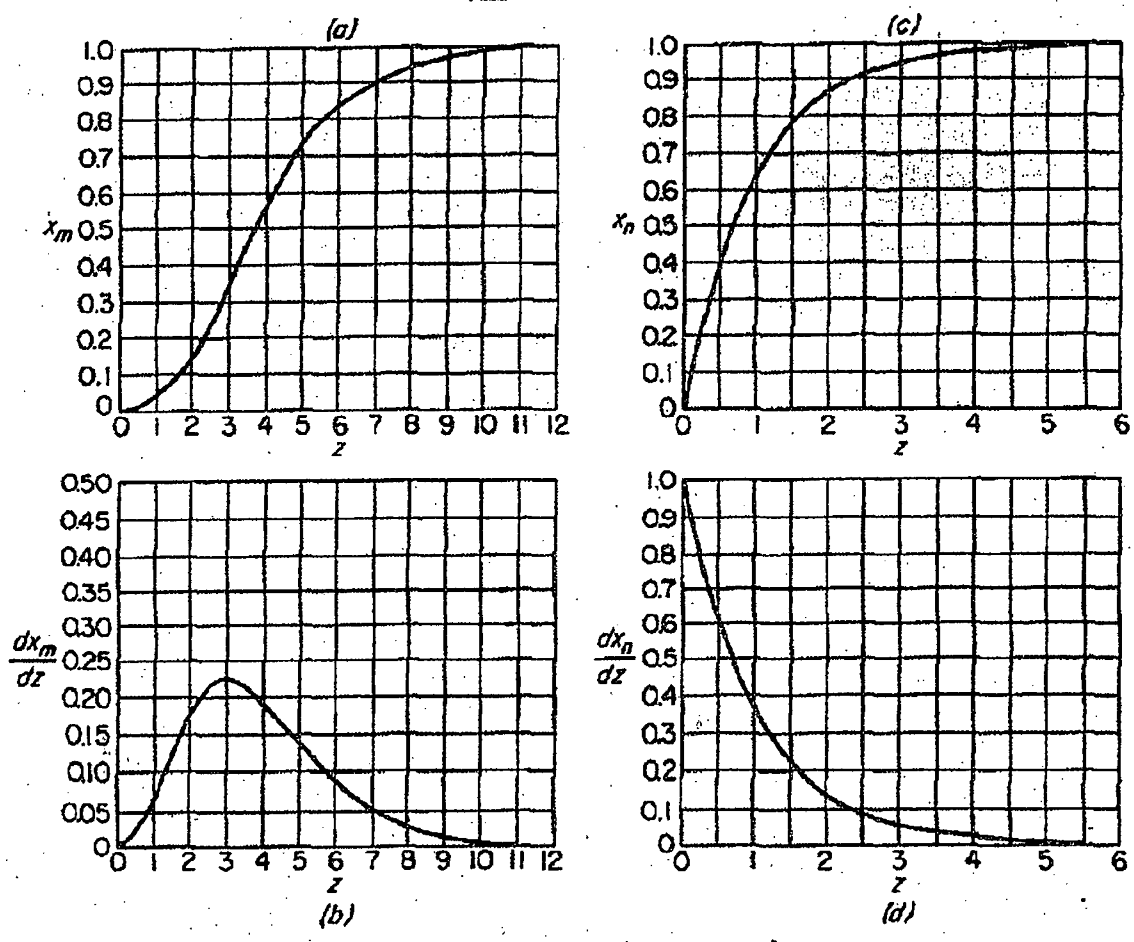
(b) state four characteristics of the Normal Distribution, and write on its usefulness by including a discussion on the z-test. **(12)**

(c) Derive the formulas for Linear Mean and Mean Linear Diameters (All symbols and parameters used must be FULLY defined). **(8)**

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

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

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



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 = $\sqrt{2}$			
	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

$$
\left.
\begin{array}{ll}
n = 4{\cdot}65, & \mathrm{Re} < 0{\cdot}2, \\
n = 4{\cdot}35\,\mathrm{Re}^{-0{\cdot}03}, & 0{\cdot}2 < \mathrm{Re} < 1, \\
n = 4{\cdot}45\,\mathrm{Re}^{-0{\cdot}1}, & 1 < \mathrm{Re} < 500, \\
n = 2{\cdot}39, & \mathrm{Re} > 500.
\end{array}
\right\}
$$

L-3/T-2/CHE **Date : 12/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

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.
Graph paper will be required.

1. (a) Briefly discuss the evolution of Biochemical Engineering as a new discipline. **(10)**
(b) Compare the key characteristics of Prokaryotic cells and Eukaryotic cells with appropriate images. **(12)**
(c) Briefly discuss Nucleic Acids and Nucleotides. Write down the characteristic comparison between DNA and RNA. **(13)**

2. (a) Briefly explain the roles of carbohydrates in cells. Give appropriate examples of disaccharides and polysaccharides (names and chemical structures). **(10)**
(b) Briefly discuss Steroids and their applications? Give examples of different Steroids. **(10)**
(c) Briefly explain Enzyme Inhibition and Inhibited Enzyme Kinetics. Differentiate between competitive inhibitors, non-competitive inhibitors, and uncompetitive inhibitors with respect to kinetic schemes and characteristic plots. **(15)**

3. (a) What is Food preservation and spoilage? Briefly explain the primary sources of microorganisms in foods. **(13)**
(b) Briefly explain irradiation techniques and processes to preserve food items. **(12)**
(c) Explain the nature and function of microorganisms in nitrogen cycle. **(10)**

4. (a) Explain pH and temperature effects on Enzyme Denaturation with appropriate equations and graphical representation. **(14)**
(b) Briefly explain Enzymatic function based on Activation energy and molecular aspects. **(6)**
(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)**

V_0 (mmol hydrolyzed/1-min		S_0 (mol/1)
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

Contd P/2

CHE 473

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

(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.

SECTION-B

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

5. (a) Define D-value, z-value and F-value during sterilization. Briefly explain with relevant plots and equations. **(10)**

(b) Write down few important characteristics of a good filter medium used for sterilization. **(5)**

(c) For a yeast fermentation reaction, initial sugar concentration is 80 g/l. The following cell optical density (OD) was measured at wavelength 610 nm. If OD is linear in cell density with a value of 0.15 equal to 0.1 mg cell dry weight per milliliter, evaluate the specific growth rate, doubling time. lag time, specific death rate and yield of biomass. **(20)**

Time (h)	*OD*	*Time (h)*	*OD*
0	0.09	6	0.98
0.5	0.1	6.5	0.99
1.0	0.1	7.0	0.9
1.5	0.15	7.5	0.8
2	0.2	8	0.69
3	0.4	9	0.45
4	0.71	10	0.32
5	0.98	11	0.25
5.5	0.98		

6. (a) What are the methods of biomass measurement? Draw typical biomass growth curves for different methods. **(5)**

(b) Draw typical product formation and substrate consumption curves for the following reactions: **(5)**

(i) $S \rightarrow R \rightarrow P$;

(ii) $S \rightarrow R$; $R \rightarrow P$

(c) List the benefits of fermentation reaction over regular chemical reaction. Draw the activation energy plots for the same reaction following two routes and explain the differences. **(5+5=10)**

(d) What are the basic requirements of a clean room? List five major types of sterilization methods used in the industries. **(4+5=9)**

(e) Draw temperature profile and viable cell number with time during thermal batch sterilization. Label different regions. **(6)**

Contd P/3

CHE 473

7. (a) List 5 major ELISA techniques and state one situation for each technique where that technique is preferable over others. **(10)**

(b) With the help of neat sketch, explain the principles of direct and indirect ELISA techniques. **(10)**

(c) A 15-m^3 chemostat is operated with dilution rate of 0.1 h^{-1}. A continuous sterilizer with steam injection and flash cooling delivers sterilized medium to the fermenter. Medium in the holding section of the sterilizer is maintained at 130°C. The concentration of contaminants in the raw medium is 10^5 ml^{-1}; an acceptable contamination risk is one organism every 3 months. The Arrhenius constant and activation energy for thermal death are estimated to be 7.5×10^{39} h^{-1} and 288.5 kJ $gmol^{-1}$, respectively. The sterilizer pipe inner diameter is 12 cm. At 130 °C the liquid density is 1000 kg m^{-3} and the viscosity is 4 kg m^{-1} h^{-1}. **(15)**

(i) What is the holding time for sterilization?

(ii) Determine the length of the holding section.

8. (a) With the help of relevant sketches, explain the working principle of the Moving Bed Bioreactor for wastewater treatment. List some of the advantages of this type of bioreactors. **(8+6=14)**

(b) Draw a schematic of typical activated sludge (AS) process and label the important sections. What are the possible disturbances that could occur in AS process? Suggest some modification that could improve the performance of AS process. **(6+3+5=14)**

(c) With the help of appropriate reactions, discuss the differences between BOD and COD. Why BOD is not preferable in some cases? **(4+3=7)**

L-3/T-2/CHE **Date : 12/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

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) List at least five major parameters and their typical standard values that are considered for the disposal of industrial wastewater in inland surface water according to ECR 1997. **(5)**

(b) A city discharges 25 million gallons per day of domestic sewage into a stream whose typical rate of flow is 250 cubic feet per second. The velocity of the stream is approximately 3 miles per hour. The temperature of the sewage is 21 °C, while the temperature of the stream is 15 °C. The 20 °C BOD_5 of the sewage is 180 mg/l, while that of the stream is 1.0 mg/l. The sewage contains no DO, but the stream is 90% saturated at upstream of the discharge. At 20 °C, deaeration constant (the BOD rate constant) k_1 is estimated to be 0.34 per day while reaeration constant k_2 is 0.65 per day. **(30)**

(i) Determine D_c and its location

(ii) Estimate the 20 °C BOD_5 of a sample taken at x_c.

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

2. (a) Write short notes on “anaerobic fermentation” and “anaerobic respiration”. **(7)**

(b) How much methane gas can be generated through complete anaerobic degradation of 1 kg of COD at STP? **(7)**

(c) Discuss the limitations of anaerobic process. **(7)**

(d) List the factors that can affect the activated sludge process performance for the treatment of wastewater. **(7)**

(e) Why is nutrient removal important? Explain phosphorous removal mechanism from EBPR process. **(7)**

3. (a) Explain the kjeldahl nitrogen removal mechanism from wastewater. **(6)**

(b) Define coagulation and flocculation. Describe electrical double layer theory of coagulation with a neat sketch. **(10)**

(c) A square rapid mixing basin with a depth of water equal to 1.25 times the width is to be designed for a flow of 7570 m^3/d. The velocity gradient (G) is to be 790 s^{-1}, the detention time is 40 s, the operating temperature is 10° C and the turbine shaft speed is 100 rpm. Determine: **(19)**

Contd P/2

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Contd... Q. No. 3(c)

(i) The basin dimensions

(ii) Power required. Select the motor needed for the impeller if the efficiency of the motor and gearbox is 70%. Assume motors come in sizes of 1, 2.5, 5 and 7.5 hp. 1 hp = 745.7 W or J/s.

(iii) Impeller diameter.

(Hint: $P = G^2V\mu$ and $P = 6.3\rho D^5N^3$). All symbols have their usual meanings.

4. (a) Write a short note on Environmental Ethics. **(6)**

(b) Define the followings in context of wastewater characteristics: **(8)**

(i) VSS and FSS

(ii) BOD vs COD

(iii) TOC vs DOC

(iv) Hardness and alkalinity.

(c) How can you obtain environmental clearance certificate for red category industries according to ECR 1997? **(9)**

(d) Describe a conventional activated sludge process for wastewater treatment with a neat sketch.. **(12)**

SECTION-B

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

5. (a) How can you classify air pollutants on the basis of their origin? – Explain their formation behavior with examples. **(15)**

(b) Why does USEPA consider some air pollutants as hazardous air pollutants (HAPs)? - State briefly with examples and their sources? **(12)**

(c) Stratospheric ozone is beneficial to living beings whereas ground level ozone is detrimental to living beings – Clarify the statement in terms of air pollution science. **(8)**

6. (a) Why airborne PM having aerodynamic diameters of $\leq 10\mu m$ is hazardous for human health? – Explain with examples. **(10)**

(b) How can you characterize a polluting source a point source? Is emission from point source higher than area source? Give justification to your answer. **(18)**

(c) Name some sources of inorganic Arsenic and Lead in the air of Bangladesh. **(7)**

Contd P/3

CHE 481

7. (a) How does airborne PM affect the visibility? - Explain the matter with scientific phenomena. **(10)**

   (b) For a cyclone separator, derive the relationship of separation efficiency for mixed flow. List all the assumptions you make to derive this relationship. **(15)**

   (c) Compute the separation efficiency of a gravity settler that has a height (H) = 2 m, Length (L) = 8 m and the emission stream average velocity of (Vavg) = 0.8 m/s. The average particle diameter of the emission stream is 10 μm. Assume stokes' law for both the block and mixed flow models. **(10)**

8. (a) Why does thermal turbulence take place in the atmosphere? Explain the phenomena in terms of temperature and pressure profiles in the troposphere. **(7)**

   (b) Theoretically, why is the environmental lapse rate smaller than dry adiabetic lapse rate? What may be the fate of ground level pollutant at around 11 PM after a shiny day if the wind speed remains very low? – Explain your answer with the help of atmospheric stability. **(8)**

   (c) Fumigation and trapping type plums are considered to be the most polluting type plumes in ground level pollution. Justify your answer with necessary temperature, velocity and plume dispersion diagram. **(13)**

   (d) What are the possible health hazards due to exposure to different levels of noise (db)? **(7)**

Table C-1
Physical Properties of Water (SI Units)[a]

Temperature, °C	Specific weight γ, kN/m³	Density[b] ρ, kg/m³	Modulus of elasticity[b] $E/10^6$, kN/m²	Dyamics viscosity, $\mu \times 10^3$, N·s/m²	Kinematic viscosity, $\nu \times 10^6$, m²/s	Surface tension[c] σ, N/m	Vapor pressure p_v, kN/m²
0	9.805	999.8	1.98	1.781	1.785	0.0765	0.61
5	9.807	1000.0	2.05	1.518	1.519	0.0749	0.87
10	9.804	999.7	2.10	1.307	1.306	0.0742	1.23
15	9.798	999.1	2.15	1.139	1.139	0.0735	1.70
20	9.789	998.2	2.17	1.002	1.003	0.0728	2.34
25	9.777	997.0	2.22	0.890	0.893	0.0720	3.17
30	9.764	995.7	2.25	0.798	0.800	0.0712	4.24
40	9.730	992.2	2.28	0.653	0.658	0.0696	7.38
50	9.689	988.0	2.29	0.547	0.553	0.0679	12.33
60	9.642	983.2	2.28	0.466	0.474	0.0662	19.92
70	9.589	977.8	2.25	0.404	0.413	0.0644	31.16
80	9.530	971.8	2.20	0.354	0.364	0.0626	47.34
90	9.466	965.3	2.14	0.315	0.326	0.0608	70.10
100	9.399	958.4	2.07	0.282	0.294	0.0589	101.33

[a] Adapted from Vennard and Street (1975).
[b] At atmospheric pressure.
[c] In contact with air.

= 4 =

Table D–2
Dissolved-oxygen concentration in water as a function of temperature and barometric pressure (salinity = 0 ppt)[a]

Temp, °C	Dissolved-oxygen concentration, mg/L									
	Barometric pressure, millimeters of mercury									
	735	740	745	750	755	760	765	770	775	780
0	14.12	14.22	14.31	14.41	14.51	14.60	14.70	14.80	14.89	14.99
1	13.73	13.82	13.92	14.01	14.10	14.20	14.29	14.39	14.48	14.57
2	13.36	13.45	13.54	13.63	13.72	13.81	13.90	14.00	14.09	14.18
3	13.00	1109	13.18	13.27	13.36	1145	13.53	13.62	13.71	13.80
4	12.66	12.75	12.83	12.92	13.01	13.09	13.18	13.27	13.35	13.44
5	12.33	12.42	12.50	12.59	12.67	12.76	12.84	12.93	13.01	13.10
6	12.02	12.11	12.19	12.27	12.35	12.44	12.52	12.60	12.68	12.77
7	11.72	11.80	11.89	11.97	12.05	12.13	12.21	12.29	12.37	12.45
8	11.44	11.52	11.60	11.67	11.75	11.83	11.91	11.99	12.07	12.15
9	11.16	11.24	11.32	11.40	11.47	11.55	11.63	11.70	11.78	11.86
10	10.90	10.98	11.05	11.13	11.20	11.28	11.35	11.43	11.50	11.58
11	10.65	10.72	10.80	10.87	10.94	11.02	11.09	11.16	11.24	11.31
12	10.41	10.48	10.55	10.62	10.69	10.77	10.84	10.91	10.98	11.05
13	10.17	10.24	10.31	10.38	10.46	10.53	10.60	10.67	10.74	10.81
14	9.95	10.02	10.09	10.16	10.23	10.29	10.36	10.43	10.50	10.57
15	9.73	9.80	9.87	9.94	10.00	10.07	10.14	10.21	10.27	10.34
16	9.53	9.59	9.66	9.73	9.79	9.86	9.92	9.99	10.06	10.12
17	9.33	9.39	9.46	9.52	9.59	9.65	9.72	9.78	9.85	9.91
18	9.14	9.20	9.26	9.33	9.39	9.45	9.52	9.58	9.64	9.71
19	8.95	9.01	9.07	9.14	9.20	9.26	9.32	9.39	9.45	9.51
20	8.77	8.83	8.89	8.95	9.02	9.08	9.14	9.20	9.26	9.32
21	8.60	8.66	8.72	8.78	8.84	8.90	8.96	9.02	9.08	9.14
22	8.43	8.49	8.55	8.61	8.67	8.73	8.79	8.84	8.90	8.96
23	8.27	8.33	8.39	8.44	8.50	8.56	8.62	8.68	8.73	8.79
24	8.11	8.17	8.23	8.29	8.34	8.40	8.46	8.51	8.57	8.63
25	7.96	8.02	8.08	8.13	8.19	8.24	8.30	8.36	8.41	8.47
26	7.82	7.87	7.93	7.98	8.04	8.09	8.15	8.20	8.26	8.31
27	7.68	7.73	7.79	7.84	7.89	7.95	8.00	8.06	8.11	817
28	7.54	7.59	7.65	7.70	7.75	7.81	7.86	7.91	7.97	8.02
29	7.41	7.46	7.51	7.57	7.62	7.67	7.72	7.78	7.83	7.88
30	7.28	7.33	7.38	7.44	7.49	7.54	7.59	7.64	7.69	7.75

(continued)