L-3/T-2/CHE **Date : 09/06/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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**.

Normal graph papers are to be supplied

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

   (b) Ammonia gas is diffusing at steady state through N_2 by equimolar counter diffusion in a conduit 1 m long at 25°C and a total pressure of 101.32 kPa abs. The partial pressure of ammonia gas at the left end is 24.5 kPa and at the other end 4.033 kPa. The cross section of the conduit is circular, the radius being 0.05 m at the left end and tapering uniformly to 0.025 m at the right end. Calculate the molar flux of ammonia. The diffusivity of ammonia in N_2 is $D = 0.23 \times 10^{-4}$ m^2/s. **(20)**

2. (a) The penetration theory of mass transfer was proposed after 30 years of when the film theory was first introduced in 1901 by Nernst. Do you think the penetration theory is an improvement over the film theory? Justify your answer. **(10)**

   (b) What do you understand by the information that the Sherwood number of a mass transfer process is close to unity? Explain. **(10)**

   (c) Bromine is rapidly dissolved in water in a stirred tank. Its concentration is about half saturated in 3 minutes. How long will it take to make it 99% saturated? **(15)**

3. A distillation column is separating a feed that is 40 mole% methanol and 60 mole% water. The two-phase feed is 60% liquid. Distillate product should be 92 mole% methanol and bottoms 4 mole% methanol. A total reboiler and a total condenser are used. Reflux is a saturated liquid. Operation is at 101.3 kPa. Assume constant molal overflow, and use $^L/_D = 0.9$. Under these conditions metal pall rings with $H_G = 1.3$ ft and $H_L = 0.8$ ft are used for the separation. Determine the required heights of both the enriching and stripping sections. Equilibrium data are given below: **(35)**

Contd P/2

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Contd... Q. No. 3

Table for VLE data of Methanol/Water (P = 1 atm)

Mole% Methanol	
Liquid	Vapor
0	0
4.0	23.0
10.0	41.8
20.0	57.9
40.0	72.9
60.0	82.5
80.0	91.5
95.0	97.9
100	100

4. Component A is being separated from a gas mixture of A and B in a wetted-wall absorption column with the liquid solvent flowing downward along the wall. At a certain point in the tower the bulk gas concentration. y_A is 0.14 mole fraction and the bulk liquid x_a is 0.007 mole fraction. The tower is operating at 30°C and 1 atm. Henry's law constant, H for component A in the solvent at 30°C is 1800 atm/mole frac. The film mass transfer coefficients for component A are **(35)**

$k_x = 1.55$ lbmole/hr-ft^2

$k_y = 1.03$ lbmole/hr-ft^2

Consider diffusion through stagnant medium and calculate the following:

(i) Interface compositions of A i.e. y_{Ai} and x_{Ai}

(ii) Mass flux

(iii) Overall mass transfer coefficient.

SECTION – B

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

5. (a) Draw the following typical curves for constant drying conditions, **(15)**

(i) Moisture content and drying rate as a function of time

(ii) Drying rate as a function of moisture content

identify the different periods of drying on the above mentioned plots.

(b) 1 Mg (1 tonne) of dry mass of a non-porous solid is dried under constant drying conditions and at a air velocity of 0.75 m/s. The area of drying surface is 55 m^2. If the initial rate of drying is 0.3 g/m^{2}s, how long will it take to dry the material from 0.15 to 0.025 kg water/kg dry solid? The critical moisture content of the material may be taken as 0.125 kg water/kg dry solid. If the air velocity were increased to 4.0 m/s, what would be the anticipated saving in time if the process is surface evaporation controlled? **(20)**

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6. (a) Explain what is 'Breakthrough curve' with the help of appropriate diagrams. **(5)**

(b) For adsorption in a fixed bed plot the typical concentration profiles and breakthrough curves. **(10)**

(c) A 1 m^3 volume of a mixture of air and acetone vapor is at a temperature of 303 K and total pressure of 100 kN/m^2. If the relative saturation of the air by acetone is 40 percent, how much activated carbon must be added to the space in order to reduce the value to 5 percent at 303 K? **(20)**

If 1.6 kg carbon is added, what is relative saturation of the equilibrium mixture assuming the temperature be unchanged? The vapour pressure of acetone at 303 K is 37.9 kN/m^2 and the adsorption equilibrium data for acetone on carbon at 303 K are:

Partical pressure of acetone $\times 10^{-2}$ (N/m^2)	0	5	10	30	50	90
x_r (kg acetone/kg carbon)	0	0.14	0.19	0.27	0.31	0.35

7. (a) Explain the following membrane separation processes with the help of necessary diagrams. **(20)**

(i) Reverse osmosis, and

(ii) Pervaporation

Discuss their applications mentioning appropriate examples. Also, highlight the relative advantages and disadvantages of these two methods.

(b) A stream at 220 atmosphere and 100°C containing 27.3% NH_3, 54.5% H_2, and 18.2% N_2 is currently being recycled to an ammonia synthesis reactor. You want to feed it through a hollow fibre module with a fibre volume fraction of 0.5 to recover 90% of the ammonia. The module's membranes are 240 micrometers in diameter, have a permeability, P, of 4.0 $\times$ 10^{-5} cm^2/sec, and a selective layer thickness, l, equal to 35 micrometers. How long should gas spend in this module? **(15)**

8. (a) 0.08 m^3/s of air at 305 K and 60% humidity is to be cooled to 275 K. Calculate, by use of a psychrometric chart, the amount of heat to be removed for each 10 deg K interval of the cooling process. What total mass of moisture will be deposited? What is the humid heat of the air at the beginning and end of the process? **(15)**

(b) Estimate the height and base diameter of a natural draught hyperbolic cooling tower which will handle a flow of 5000 kg/s water entering at 300 K and leaving at 294 K. The dry-bulb air temperature is 287 K and ambient wet-bulb temperature is 284 K. The relation between, duty coefficient D_t of a tower and performance coefficient C_t is given as, **(20)**

$$D_t = \frac{19.50\, A_b Z_t^{0.5}}{C_t^{1.5}}$$

and, the duty coefficient, D_t is given by the following equation,

$$\frac{W_L}{D_t} = 0.00369 \frac{\Delta H'}{\Delta T} \left(\Delta T' + 0.0752\, \Delta H'\right)^{0.5}$$

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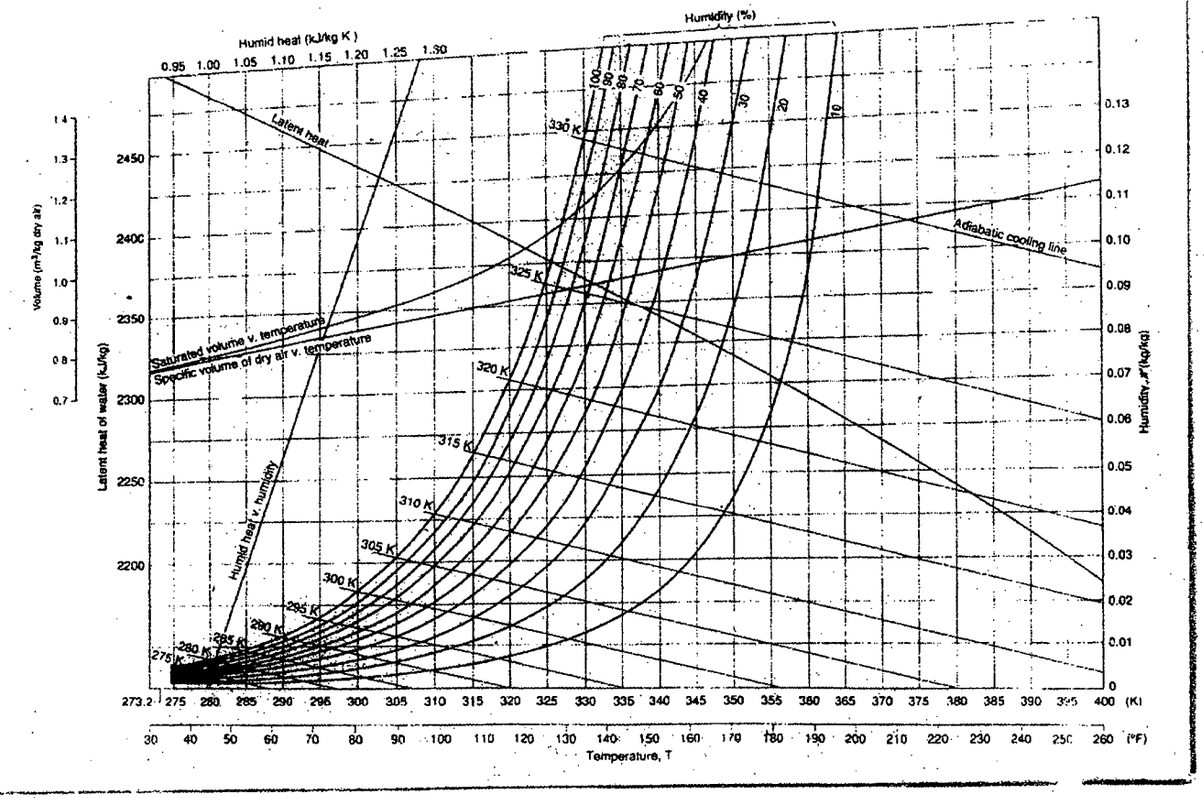

Figure for Q. 8(a)

L-3/T-2/CHE Date : 12/05/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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) A circular silo 10 ft in diameter contains barley with a bulk density of 39 lb/ft^3. What are the vertical and lateral pressures, in lb$_f$/ft^2, at the base of the silo if the depth of the barley is 40 ft? If it is 80 ft? Given, K' = 0.40; μ' = 0.45. **(10)**

   (b) 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 15000 rpm. The fish oil has a density of 0.95 g/cm^3 and a viscosity of 50 cp at 25°C. The radii of the inner and outer overflow dams are 1.246 in. and 1.250 in., respectively. 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 weight percent fish oil. **(15)**

   (c) Determine outlet dam heights and throughput that would permit the tubular bowl centrifuge of 1(b) to separate droplets down to a critical diameter of 1 micron from both oil and water phases. **(10)**

2. (a) A gravity settling tank is to be used to clean wastewater from an oil refinery. The waste stream contains 1% oil by volume (specific gravity of the oil is 0.87) as small drops ranging in size between 10 and 500 microns. The tank is rectangular and measures 3 m wide and 2 m deep. Provision is made at the discharge end for the clean water to be continuously removed from the bottom of the tank. Periodic skimming of the liquid surface at the discharge end removes the accumulated oil. If 6.3 m^3/s of wastewater is to be processed, how long must the setting tank be? **(20)**

   (b) A mixture of coal and sand in particle sizes smaller than 20 mesh is to be completely separated by screening and then elutriating each of the cuts from the screening operation with water as the elutriating fluid. Recommend a screen size such that the oversize cut can be completely separated into coal and sand fractions by water elutriation. What water velocity will be required? The specific gravity for sand and coal is 2.65 and 1.35, respectively. **(15)**

3. (a) It is required to filter a slurry to produce 2.25 m^3 of filtrate per working day of 8 hours. The process is carried out in a plate-and-frame filter press with 0.45 m square frames and a working pressure difference of 348.7 kN/m^2. The pressure is built up slowly over a period of 300 s and, during this period, the rate of filtration is maintained constant.

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Contd ... Q. No. 3(a)

When a sample of the slurry is filtered, using a pressure difference of 66.3 kN/m^2 on a single leaf filter of filtering area 0.05 m^2, 400 cm^3 of filtrate is collected in the first 300s of filtration and a further 400 cm^3 is collected during the following 600s. Assuming that the dismantling of the filter press, the removal of the cakes and the setting up again of the filter press takes an overall time of 300s, plus (and) additional 180s for each cake produced, what is the minimum number of frames that need to be employed? The resistance of the filter cloth may be taken as the same in the laboratory tests as in the plant. **(15)**

(b) In the laboratory filtration tests on a precipitate of $CaCO_3$ suspended in water, a specially designed plate-and -frame filter press with a single frame was used. The frame had a filtering area of 0.283 ft^2 and a thickness of 1.18 in. All tests were conducted at 66°F and with a slurry containing 7.23% by weight $CaCO_3$. The density of the dried cake was 100 lb/ft^3. Test results on one run are given below: ΔP = 40 psi = constant.

Volume of Filtrate (L)	Time (s)	Volume of Filtrate (L)	Time (s)	Volume of Filtrate (L)	Time (s)
0.2	1.8	1.2	20.5	2.2	57.7
0.4	4.2	1.4	26.7	2.4	67.2
0.6	7.5	1.6	33.4	2.6	77.3
0.8	11.2	1.8	41.0	2.8	88.7
1.0	15.4	2.0	48.8	-	-

Determine the filtrate volume equivalent in resistance to the filter medium and piping, the specific cake resistance, the cake porosity, and the cake specific surface area. **(20)**

4. (a) What are the requirements of an MSMPR crystallizer model? Derive the fundamental relation of the MSMPR crystallizer. **(6+6=12)**

   (b) What do you mean by PREDOMINANT CRYSTAL SIZE? Derive the expression for B° of an MSMPR crystallizer. **(3+5=8)**

   (c) 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) Plot the cumulative screen analysis of the theoretical product, and (ii) determine the required growth rate and the necessary nucleation rate. **(15)**

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SECTION – B

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

5. (a) 12 kg of spherical resin particles of density 1200 kg/m^3 and uniform diameter 70 μm are fluidized by water in a vessel of diameter 0.3 m and form an expanded bed of height 0.25 m.

   (i) Calculate the difference in pressure between the base and top of the bed. (Hint: Apply the mechanical energy equation) **(10)**

   (ii) If the flow rate of water is increased to 7 cm^3/s, what will be the resultant bed height and bed voidage? **(15)**

   (b) With reference to the "Normal Distribution" explain - Mean, Median and Mode. What is skewness and what does it indicate? **(10)**

6. (a) The reaction of a catalytic reformer contains spherical catalyst particles of diameter 1.46 mm. The packed volume of the reactor is to be 3.4 m^3 and the void fraction is 0.25. The reactor feed is a gas of density 30 kg/m^3 and viscosity 2×10^{-5} Pas flowing at a rate of 11,320 m^3/h. The gas properties may be assumed constant. The pressure loss through the reactor is restricted to 68.95 kPa. Calculate the cross-sectional area for flow and the bed depth required. **(18)**

   (b) Using the illustration of the colloidal Double Layer explain Zeta Potential. Show how Zeta Potential is the fundamental concept in the theory of coagulation - give applications. **(17)**

7. (a) A rotary drum with a filter area of 3m^2 operates with an internal pressure of 71.3 kN/m^2 below atmospheric and with 30% of its surface submerged in the slurry. Calculate the rate of production of filtrate and the thickness of cake when it rotates at 0.0083 Hz, if the filter cake is incompressible and the filter cloth has a resistance equal to that of 1 mm of cake. It is desired to increase the rate of filtration by raising the speed of rotation of the drum. If the thinnest cake that can be removed from the drum has a thickness of 5 mm, what is the maximum rate of filtration that can be achieved and what speed of rotation of the drum is required? The voidage of the cake is 0.4, the specific resistance of the cake is 2×10^{12} m^{-2}, the density of solids is 2000 kg/m^3, the density of filtrate is 1000 kg/m^3, the viscosity of filtrate is 10^{-3} Ns/m^2 and the slurry concentration is 20% by mass of solids. **(17)**

   (b) The size analysis of a powdered material on a mass basis is represented by a straight line from 0% mass at 1 μm particle size to 100% mass at 101 μm particle size. Calculate both surface-based mean diameters of the particles constituting the system. **(4+4=8)**

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(c) Explain fully how the "Buoyand Force" on a spherical particle can be derived by solving the Navier-Stokes equation and then performing some mathematical derivations for "Creeping Flow Around a Sphere". (No solution needed; step by step explanation only) **(10)**

8. (a) Give a sketch of Cutaway view of a vertical-leaf filter and sectional diagram showing filter-leaf construction. Briefly explain the working principles. **(15)**

(b) Show that the ratio of specific surfaces (η) and the sphericity (ψ) may be related by the equation **(8)**

$$\psi = \frac{\overline{D}_p}{D_o} \times \frac{1}{\eta}$$

(c) Write notes on (any 2(two)): **(6+6=12)**

(i) Boundary layer separation

(ii) The Carmen-kozency model for pressure drop (full derivation not required)

(iii) Transport disengaging height (TDH)

(iv) Flocculation by polyelectrolytes.

Contd---- P/5

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	$2\frac{1}{2}$	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

Moment Equations for MSMPR Crystallizer:

$$\mu_0 = 1 - e^{-z}$$

$$\mu_1 = 1 - (1+z)e^{-z}$$

$$\mu_2 = 1 - \left(1+z+\frac{z^2}{2}\right)e^{-z}$$

$$\mu_3 = 1 - \left(1+z+\frac{z^2}{2}+\frac{z^3}{6}\right)e^{-z}$$

Contd ---- P/6

ADDITIONAL DATA

Richandson-Zaki coefficient, n:

$n = 4.65$; $Re_p < 1$

$n = 4.4\, Re_p^{-0.1}$; $1 \leq Re_p \leq 500$

$n = 2.4$; $Re_p > 500$

Drag Coefficient

$C_D = \frac{24}{N_{Re}}$; $N_{Re} < 1$

$C_D = \frac{24}{N_{Re}}\left[1 + 0.15 N_{Re}^{0.7}\right]$; $1 \leq N_{Re} \leq 1000$

$C_D = 0.44$; $N_{Re} > 1000$

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L-3/T-2/CHE **Date : 19/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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) Draw "Silvan Chart" showing the main features. Write a short account to show how to use it. **(14)**

   (b) What is critical particle diameter (CPD)? In which mechanical separator CPD concept is applied? Show the dimensional relationship of this mechanical separator with simple diagram. **(15)**

   (c) Describe briefly the mechanism of separation action of wet scrubbers. Draw simple sketches to show different types of wet scrubbers. **(17⅔)**

2. (a) Write down the working principles of reaction and impulse turbines with simple schematics. **(10)**

   (b) Write the selection guides for different types (according to steam usages) of steam turbines. **(10)**

   (c) With neat sketches explain the working principle of a Droop Governor. **(10)**

   (d) What type of combined staging will you recommend for a multistage impulse turbine with high energy difference between inlet and outlet stream? Show the steam flow path and pressure-velocity relationship along the length of the recommended turbine. **(16⅔)**

3. (a) Discuss the importance of size reduction (crushing and grinding) operations in chemical and mining industries with appropriate examples. **(10)**

   (b) Classify the size reduction equipment based on feed and product size. Show graphically the energy requirement of different size reduction equipment. **(10)**

   (c) How do different forces arise during size reduction operation? In how many ways, is the applied energy utilized in size reduction operation? **(10)**

   (d) Describe with neat sketch. How the grinding actions are obtained in a ball mill. **(16⅔)**

4. (a) Why are intercoolers used with multistage reciprocating compressor? How does intercoolers contribute to the efficiency of multistage compressor? — Explain with the help of necessary diagram. **(16⅔)**

   (b) What is set pressure and back pressure of a relief valve? Explain the working principle of a balanced safety valve with neat schematic diagram. **(10)**

   (c) Describe the working principle of an ESP with simple diagram. **(10)**

   (d) Write the guidelines for installing safety devices on a pressure vessel. **(10)**

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SECTION – B

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

5. (a) Why multiple effect evaporators are used? Discuss the merits and demerits of different feeding schemes/arrangements of multiple effect evaporator. **(16⅔)**

(b) A client wants to concentrate a heat sensitive fruit juice from 10% to 50%. What type of evaporator should you be suggesting him to use and why? **(10)**

(c) Determine the heating area required for the production of 10,000 lb/hr of 50% NaOH solution from a 10% NaOH feed entering at 100°F. Evaporation is to be carried out in a single effect evaporator for which an overall coefficient of 500 Btu/hr.ft^2 °F is expected. Steam is available saturated at 50 psig, the evaporator can be operated at 10 psi vacuum relative to barometric pressure of 14.7 psia. **(20)**

6. (a) Write the names of industries in Bangladesh which use the following types of dryers and kilns. Justify your answer. **(10)**

(i) Spray dryer (ii) Rotary kiln (iii) Flash dryer (iv) Drum dryer (v) Tunnel dryer.

(b) Describe the "principle of drying" using drying rate curve for constant drying conditions. **(20)**

(c) Write down the calculation steps in designing an adiabatic direct contact dryer. **(16⅔)**

7. (a) What are the factors to be considered in designing crystallization process? **(12)**

(b) Write a short account on the different types of nucleation in a crystallization process. **(12)**

(c) Show with the help of a rough graph how power number is related to Reynolds Number for mixer with turbines and propellers. **(10)**

(d) What kind of mixing arrangement will you recommend when mixing is taking place in a tank? Draw sketch. **(12⅔)**

8. (a) What are the features that make ejectors attractive for industrial vacuum applications? What is pickup pressure in a ejector system? **(16⅔)**

(b) What is meant by centrifugal pump size $1\frac{1}{2}\times 3-13$. **(3)**

(c) Write a short notes on followings: **(9×2=18)**

(i) NPSH (ii) Characteristics Curves.

(d) It is necessary to pump 2500 gal/min against a head of 50 ft. What type of pump might be used? **(9)**

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CHE 311

Table 1. Properties of Saturated Steam and Water.

Temp. T, °F	Vapor press. p_s, lb$_f$/in.^{2}	Specific vol., ft^3/lb		Enthalpy, Btu/lb		
		Liquid v_x	Sat. vapor v_y	Liquid H_x	Vaporization λ	Sat. vapor H_y
32	0.08854	0.01602	3,306	0.00	1075.8	1075.8
35	0.09995	0.01602	2,947	3.02	1074.1	1077.1
40	0.12170	0.01602	2,444	8.05	1071.3	1079.3
45	0.14752	0.01602	2,036.4	13.06	1068.4	1081.5
50	0.17811	0.01603	1,703.2	18.07	1065.6	1083.7
55	0.2141	0.01603	1,430.7	23.07	1062.7	1085.8
60	0.2563	0.01604	1,206.7	28.06	1059.9	1088.0
65	0.3056	0.01605	1,021.4	33.05	1057.1	1090.2
70	0.3631	0.01606	867.9	38.04	1054.3	1092.3
75	0.4298	0.01607	740.0	43.03	1051.5	1094.5
80	0.5069	0.01608	633.1	48.02	1048.6	1096.6
85	0.5959	0.01609	543.5	53.00	1045.8	1098.8
90	0.6982	0.01610	468.0	57.99	1042.9	1100.9
95	0.8153	0.01612	404.3	62.98	1040.1	1103.1
100	0.9492	0.01613	350.4	67.97	1037.2	1105.2
110	1.2748	0.01617	265.4	77.94	1031.6	1109.5
120	1.6924	0.01620	203.27	87.92	1025.8	1113.7
130	2.2225	0.01625	157.34	97.90	1020.0	1117.9
140	2.8886	0.01629	123.01	107.89	1014.1	1122.0
150	3.718	0.01634	97.07	117.89	1008.2	1126.1
160	4.741	0.01639	77.29	127.89	1002.3	1130.2
170	5.992	0.01645	62.06	137.90	996.3	1134.2
180	7.510	0.01651	50.23	147.92	990.2	1138.1
190	9.339	0.01657	40.96	157.95	984.1	1142.0
200	11.526	0.01663	33.64	167.99	977.9	1145.9
210	14.123	0.01670	27.82	178.05	971.6	1149.7
212	14.696	0.01672	26.80	180.07	970.3	1150.4
220	17.186	0.01677	23.15	188.13	965.2	1153.4
230	20.780	0.01684	19.382	198.23	958.8	1157.0
240	24.969	0.01692	16.323	208.34	952.2	1160.5
250	29.825	0.01700	13.821	218.48	945.5	1164.0
260	35.429	0.01709	11.763	228.64	938.7	1167.3
270	41.858	0.01717	10.061	238.84	931.8	1170.6
280	49.203	0.01726	8.645	249.06	924.7	1173.8
290	57.556	0.01735	7.461	259.31	917.5	1176.8
300	67.013	0.01745	6.466	269.59	910.1	1179.7
310	77.68	0.01755	5.626	279.92	902.6	1182.5
320	89.66	0.01765	4.914	290.28	894.9	1185.2
330	103.06	0.01776	4.307	300.68	887.0	1187.7
340	118.01	0.01787	3.788	311.13	879.0	1190.1
350	134.63	0.01799	3.342	321.63	870.7	1192.3
360	153.04	0.01811	2.957	332.18	862.2	1194.4
370	173.37	0.01823	2.625	342.79	853.5	1196.3
380	195.77	0.01836	2.335	353.45	844.6	1198.1
390	220.37	0.01850	2.0836	364.17	835.4	1199.6
400	247.31	0.01864	1.8633	374.97	826.0	1201.0
410	276.75	0.01878	1.6700	385.83	816.3	1202.1
420	308.83	0.01894	1.5000	396.77	806.3	1203.1
430	343.72	0.01910	1.3499	407.79	796.0	1203.8
440	381.59	0.01926	1.2171	418.90	785.4	1204.3
450	422.6	0.0194	1.0993	430.1	774.5	1204.6

Q(5)

† Abstracted from abridged edition of "Thermodynamic Properties of Steam," by Joseph H. Keenan and Fredrick G. Keyes, John Wiley & Sons, Inc., New York, 1937, with the permission of the authors and publisher.

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CHE 311

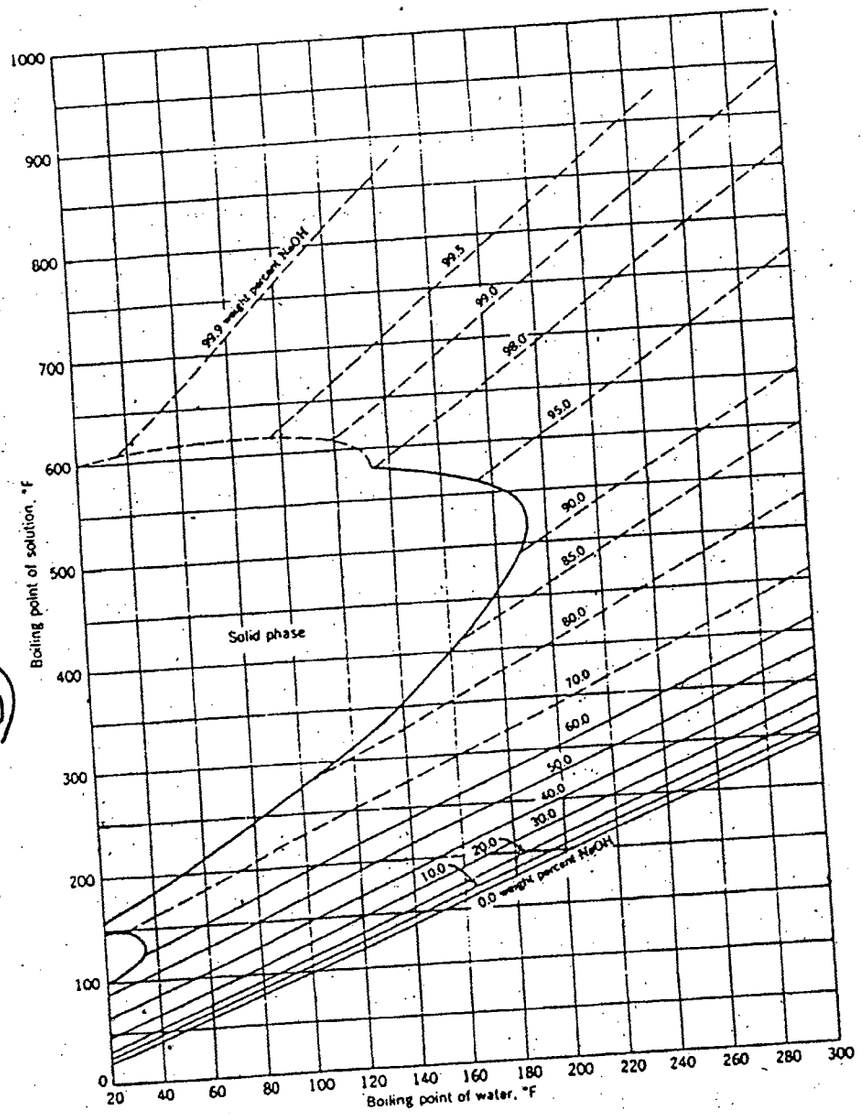

Figure 1 (a). Dühring lines for the $NaOH-H_2O$ system.

Q(5)

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ChE 311

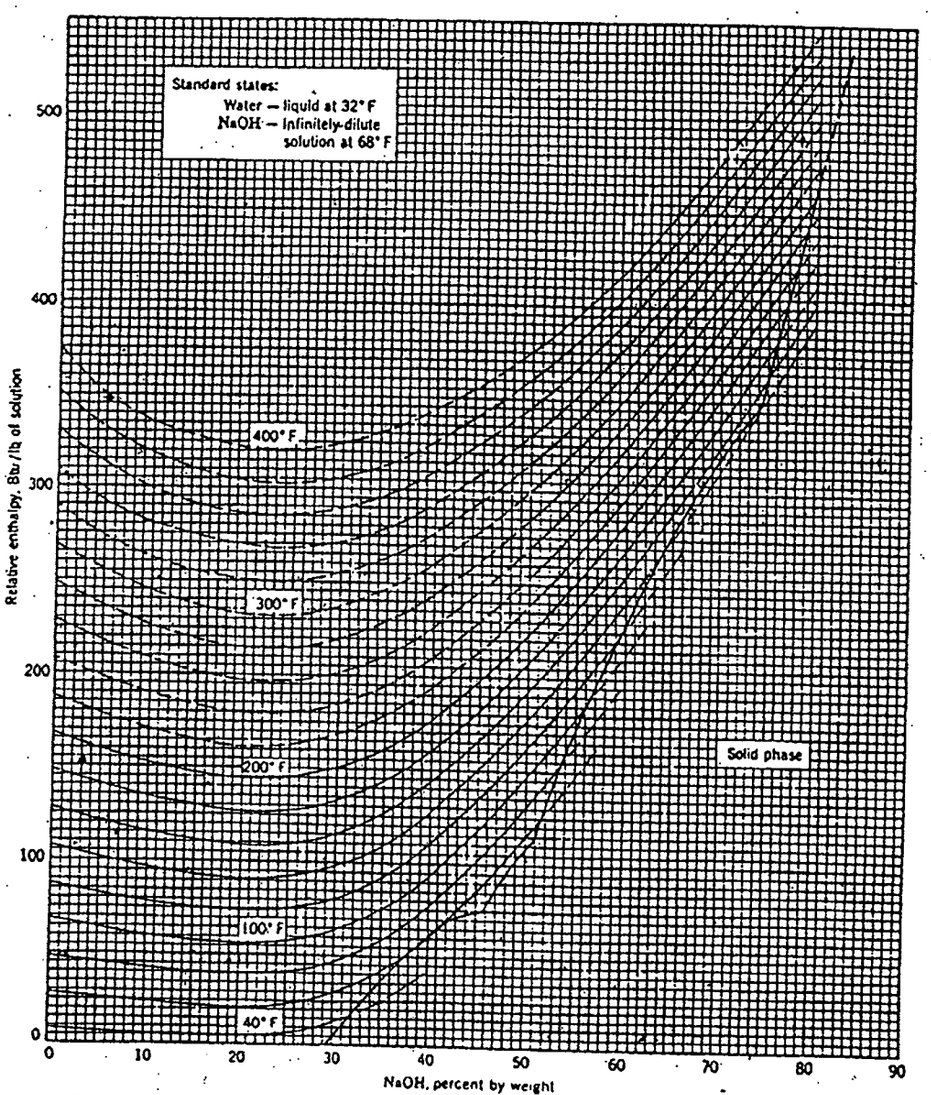

Figure 1 (b). Enthalpy-concentration diagram for aqueous solutions of NaOH under a total pressure of one atmosphere. The reference state for water is taken as liquid water at 32°F under its own vapor pressure. This reference state is identical with the one used in most steam tables (8). For sodium hydroxide, the reference state is that of an infinitely dilute solution at 68°F. [From McCabe, W. L., *Trans. A.I.Ch.E.*, *31*, p. 129 (1935), by permission of A.I.Ch.E., copyright © 1935.]

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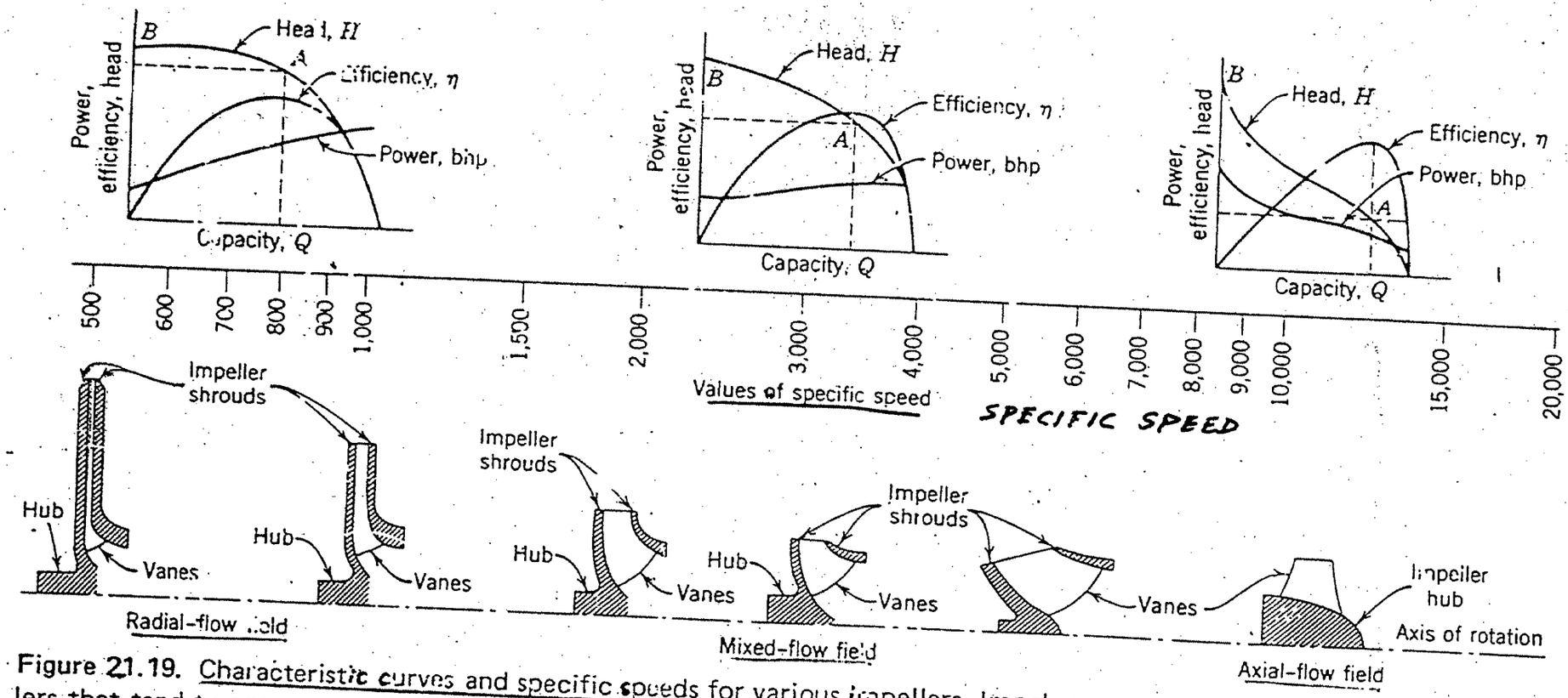

Figure 21.19. Characteristic curves and specific speeds for various impellers. Impellers that tend to promote radial flow, as in a standard centrifugal pump, operate at the lowest specific speed (up to 4200). Mixed-flow impellers, which produce both axial and radial flow, operate at higher specific speeds (4200 to 9000). Axial flow impellers operate at the highest specific speeds (above 9000). (Courtesy Worthington Pumps, Inc.)

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Siddika
26.05.13

L-3/T-2/ChE **Date : 26/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Describe the three main routes to petrochemicals from primary feed stocks. **(7)**

   (b) Draw a process flow diagram of Pikes Peak carbon dioxide removal system and explain its salient features. **(10)**

   (c) Draw and explain a generalized schematic of a typical gas treating plant. **(9)**

   (d) Explain the terms: LNG, NGL and LP-gas? **(9)**

2. (a) Discuss the major types of hydrocarbons present in petroleum crude oil. **(10)**

   (b) Describe the different types of techniques used for separating hydrocarbons from Petroleum. **(10)**

   (c) Describe different types of techniques used for identifying Petroleum hydrocarbons. **(10)**

   (d) What is BMCI (CI)? **(5)**

3. (a) Write manufacturing technologies, properties and uses of the following Petrochemicals: **(7×3=21)**

   (i) Detergent

   (ii) Acetylene

   (iii) Methanol

   (b) By drawing a PFD, explain atmospheric and vacuum distillation, residuum conversion, hydrocracking and pyrolysis for fuels and petrochemicals. **(14)**

4. (a) Describe various types of non-hydrocarbon compounds occur in crude oil and refinery streams. **(10)**

   (b) Write notes on : catalytic reforming, hydrocracking and thermal cracking. **(15)**

   (c) Describe different methods for chemical and physical characterization of crude oil quality. **(10)**

Contd P/2

CHE 433

SECTION – B

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

5. (a) Draw the relation between melting temperatures (T_m) and relative molecular mass (RMM) of materials. **(15)**

   (b) Define the term relative molecular mass (RMM). What is the RMM of a polyethylene molecule of degree of polymerization 10^4? **(8)**

   (c) From X-ray diffraction experiment of polyethylene a student got the specific volume of the crystalline fraction is $v_c = 0.989 \times 10^{-3}\ m^3kg^{-1}$. After extrapolating the volume temperature line for liquid polymers he got the yield of polyethylene at 20°C is $v_a = 1.16 \times 10^{-3}\ m^3kg^{-1}$. If a measurement of sp.volume of a polyethylene specimen yields $v = 1.042 \times 10^{-3}\ m^3kg^{-1}$, what would be the crystallinity of that specimen at 20°C? **(12)**

6. (a) Write short notes on, (i) Polypropylene, (ii) PVC, and (iii) Natural rubber. **(15)**

   (b) A bar of ideal rubber containing 5×10^{20} chains between cross-links is extended uniaxially at 20°C until its length is double the initial length. Calculate the heat gained or lost. Assume, a Gaussian network and $\langle r^2 \rangle_i = \langle r^2 \rangle_o$. **(10)**

   (c) A bar of polypropylene is of length 200 mm and has a rectangular cross-section of dimensions $25 \times 3\ mm^2$. It is subjected to a constant tensile load of 250 N acting along its length. 100 s after the load was applied the length is measured and is found to have increased by 0.5 mm. Determine the 100 s tensile creep compliance. (30)(30)

7. (a) Describe the structures of linear, branched-chain and cross-linked polymers with the help of necessary diagrams. **(10)**

   (b) Consider three blends of 2 g mass is formed from the following three sets of paraffins,

   (i) $C_{95}\ H_{192}$ and $C_{105}\ H_{212}$,

   (ii) $C_{10}\ H_{22}$ and $C_{190}\ H_{382}$, and

   (iii) $C_{10}\ H_{22}$ and $C_{1000}\ H_{2002}$.

   The 2 gm mass contains 1 gm of each of two paraffins. Calculate the number average molar mass $\overline{Mn}$ and the weight average molar mass $\overline{Mw}$ for all three sets. Discuss the dependence of $\overline{Mn}$ and $\overline{Mw}$ on the molecular masses of the Specimen used. What does the ratio $\overline{Mw}/\overline{Mn}$ infer? **(25)**

8. (a) Describe the initiation, propagation and termination steps of both anionic and cationic polymerization processes. **(20)**

   (b) Describe the synthesis of addition polymers. **(15)**

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26.05.13

L-3/T-2/ChE **Date : 26/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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** questions.

1. (a) Explain the fertilizers production routes and impact of fertilizers on human beings. Elaborate the demand and supply situation of different types of fertilizer in Bangladesh and in the world. **(25)**

   (b) Write a short note on environmental protection aspects of the fertilizer industries of Bangladesh. **(10)**

2. (a) Discuss the thermodynamic and kinetic aspects of different steps that are involved in ammonia synthesis. **(15)**

   (b) Describe briefly the distinguishing features of ammonia synthesis reactors. Point out the factors affecting ammonia synthesis reaction. **(10)**

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

3. (a) Compare the CO_2 removal processes used in Ammonia Plant. **(15)**

   (b) Point out the advantages and disadvantages of different technologies used in Urea production. Discuss the factors affecting Urea production. **(20)**

4. (a) Distinguish between Single and Tripple Superphosphates. Discuss the problems to be solved in producing Tripple Superphosphate. **(25)**

   (b) Write a short note on Potash Fertilizer manufacturing process. **(6)**

   (c) Explain the terms : Complex and Mixed Fertilizers. Point out their distinguishing features. **(4)**

SECTION – B

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

5. (a) What is the composition of wood? Write down the chemical composition of cellulose. **(4+3)**

   (b) Write down the important pulping variables of wood and wood chips? **(5)**

   (c) What is Lignin? Give two examples of Lignin monomer. **(6)**

   (d) Write a short note on Fiber Strength? **(5)**

   (e) Discuss Chemical Pulping and Papermaking process with simplified flow diagram. **(12)**

Contd P/2

CHE 441

6. (a) What is Pulping? Write down the general classification of pulping process. **(5)**

   (b) Write down the following items for Mechanical, Chemi-Mechanical, and Neutral Sulfite Semi-Chemical (NSSC) Pulping: **(12)**

   Required Chemicals, Wood Species, Pulp Properties, Uses and Yield.

   (c) Write short notes on three of the following items: **(18)**

   (i) Stone Groundwood (SGW) Mechanical Pulp,

   (ii) Refiner Mechanical Pulp (RMP),

   (iii) Kraft Pulping Process,

   (iv) Batch Digester,

   (v) Blow Tank.

7. (a) Briefly explain the impact of chemical recovery on the cost of chemical pulping process. Discuss Kraft Spent Liquor recovery cycle. **(5+15)**

   (b) Write a short note on Mechanical Pulp bleaching. **(6)**

   (c) Briefly explain the following terms for mechanical pulp bleaching: **(9)**

   (i) Kappa number,

   (ii) Permanganate number,

   (iii) Roe-number.

8. (a) What are the major steps of paper production from pulp? **(5)**

   (b) What is the function of Beating in paper making? What are the disadvantages of using beater in paper making? **(7)**

   (c) Write down the advantages and disadvantages of Cylinder Mould Type Machine for paper making. **(8)**

   (d) Briefly explain different treatment steps of wastewater generated from pulp and paper industries. **(15)**

L-3/T-2/CHE Date : 02/06/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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**.

Graph paper needs to be supplied.

1. (a) Write down the classification of microorganism belonging to the Kingdom of Protist. Give example of each class. **(5)**

   (b) What are viruses? Explain the Lytic and Lysogenic life cycles of viruses. **(15)**

   (c) Write short notes on three of the following items: **(5+5+5=15)**

   (i) Bacterial classification based on gram reaction,

   (ii) Amino Acid: structure and classifications,

   (iii) Yeast,

   (iv) Protein structure.

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

   (b) What is DNA? What are the main features of a DNA? **(6)**

   (c) Briefly explain enzymatic function based on activation energy and molecular aspects. **(6)**

   (d) Develop mechanistic model of simple enzyme kinetics for the Quasi-steady-state assumptions. **(8)**

3. (a) Discuss the procedures for determining of rate parameter K_m and $V_m$for a simple enzyme-catalyzed reaction using Linewever-Burk Plot. **(6)**

   (b) What is enzyme inhibition? Briefly discuss the classification of reversible enzyme inhibitors. **(8)**

   (c) Write a short note on substrate inhibition. **(6)**

   (d) An inhibitor (I) is added to an enzymatic reaction at a level of 1.0 g/l. The following data were obtained for K_m = 9.2 g S/l. **(15)**

Contd P/2

CHE 473

Contd... Q. No. 3(d)

v	S
0.909	20
0.658	10
0.493	6.67
0.40	5
0.333	4
0.289	3.33
0.227	2.5

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

(ii) Based on the answer to part (i), what is the value of K_I?

4. (a) Explain temperature effect on enzyme denaturation. **(5)**

(b) What is Enzyme-Linked Immunosorbent Assay (ELISA)? What are the applications of ELISA techniques? Briefly explain Direct and Indirect ELISA techniques. **(2+3+5+5=15)**

(c) Write down the categories and sources of microorganisms found in food items. **(6)**

(d) What is food preservation and spoilage? Write down the purposes of chemical preservation of food items. Give examples of natural and artificial preservatives. **(3+3+3=9)**

SECTION – B

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

Semi-log paper needs to be supplied.

5. (a) What is fermentation? 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. **(2+5+5=12)**

(b) What are biocatalysts and what are their benefits? Draw a schematic of laboratory fermenter and label all the important components. List the steps you would follow to perform a fermentation reaction in the laboratory. **(2+4+5+6=17)**

(c) Derive a simplified equation of biomass at the stationary phase, starting from the definition of biomass yield. **(6)**

6. (a) Briefly explain the Monod's equation for microbial growth kinetics. Discuss two special cases when the substrate concentration is either too high or too low. **(3+6=9)**

Contd P/3

CHE 473

Contd... Q. No. 6

(b) The following biomass and sugar concentrations were obtained during batch culture of Agrobacterium rhizogenes in a bubble-column fermenter.

Time (hr)	Biomass mg/L	Sugar Concentration g/L
0	0.07	10
1	0.15	9.2
2	0.29	8.3
3	0.6	7.7
4	1.1	6.7
5	2.3	5.8
7	9.2	4.1
9	37	2.9
12	240	1.3
15	1400	0.3
16	1280	0.19
17	1140	0.15
18	990	0.10

(i) Calculate the specific growth rate and doubling time for this culture. **(10+4=14)**

(ii) What is the yield, $Y_{x/s}$ (mg biomass/g sugar) before the stationary phase? **(5)**

(iii) When this experiment was repeated with starting sugar concentration 30 g/L, the average specific growth rate was found to be 0.8/hr. Assuming Monod's growth kinetics, estimate the half saturation constant, k_s and theoretical maximum specific growth rate (μ_{max}) for this set of experiments. **(7)**

7. (a) Define the terms 'sterilization', 'disinfection' and 'aseptic techniques'. Name five different sterilization methods used in bioprocess industries. **(6+5=11)**

(b) Briefly explain thermal destruction ratio with appropriate equation. Discuss two methods of continuous thermal sterilization with the help of process flow diagrams and temperature profiles. **(3+6+6=15)**

(c) An autoclave was used to sterilize a liquid medium from 10″/liter to 10^{-3}/liter contaminating organism. How long should it be operated at 121°C to achieve this? **(9)**

Given:

Activation Energy, E_d = 283 kJ/mol

Arrhenius Constant, A = 1.6×10^{36}/s

R = 8.3144 J/k/mol.

Contd P/4

CHE 473

8. (a) Briefly explain the typical biological treatment steps. Write a short note on trickling biological filters. **(5+5=10)**

(b) Draw a schematic diagram of an activated sludge process. Using Monod's equation for microbial growth, and material balance for biomass and substrate, derive the expression for volume of the sludge tank. **(15)**

Monod's equation for microbial growth is: $\mu_{net} = \mu_g - k_d$

Where,

μ_{net} = specific growth rate of biomass

μ_g = gross specific growth rate of biomass

k_d = microbial decay coefficient.

(c) Write short notes on any two of the following food preservation techniques: **(5+5=10)**

(i) Freezing

(ii) Chilling

(iii) Pasteurization.

L-3/T-2/CHE **Date : 02/06/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2011-2012

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) What do you understand by "Global Warming"? How will it affect us in Bangladesh? **(8)**

   (b) Write a short notes on: **(15)**

   "Different Gas Analyzer used in Environmental Lab, Chemical Engineering Department BUET."

   (c) Explain briefly the relationship between mechanical turbulence and thermal turbulence in atmosphere with respect to pollutant discharge in air. **(12)**

2. (a) What do you mean by "Air Pollution"? Name six prominent impacts of air pollution worldwide. **(8)**

   (b) Why do we need to control "Air to Fuel ratio" for automobile engine? Explain it. **(12)**

   (c) A factory releases a plume into the atmosphere on an overcast summer afternoon. At what distance downwind will the plume begin mixing downward if an inversion layer exists at a base height of 369 m and the wind speed is 1.8 m/s? [see attached Table and Figures] **(15)**

3. (a) "Hydraulic equation helps us to understand the removal measures of contaminated groundwater." — Explain. **(5)**

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

   (i) Estimation of Probability of Occurance

   (ii) Thiessen Method

   (c) Prepare a table of plotting points for an IDE curve for 10 year strom at the Dismal swamp. Compute points for each duration given in Table 3(c). **(10)**

4. (a) How do you control the noise in the transmission path? Describe it. **(20)**

   (b) Write 'Basic point source model of sound transmission'. **(5)**

   (c) Describe the different characterization methods of Noise. **(10)**

Contd P/2

CHE 481

SECTION – B

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

5. (a) What is UNCED? Write down three main goals of 'Convention on Biological Diversity' agreement signed on UNCED. **(5)**

(b) How 'National Conservation Strategy' was prepared in two phases? Write down the objectives of NCS and its strategy to overcome the obstacles. **(6+3+6=15)**

(c) What is Sustainable Environmental Management Program? Discuss the areas SEMP puts emphasis on? **(5+10=15)**

6. (a) List the historical facts which resulted visible damage on environment in the presence of environmental regulations in Bangladesh. **(10)**

(b) Which recommendations were made by National Conservation Strategy (NCS) for Sustainable Development and 'Energy and Minerals' sectors? **(8)**

(c) What is NEMPA? State its main objectives. **(7)**

(d) What are the shortcomings of ECA'95 and ECR'97? **(10)**

7. (a) Write down the steps involved in getting environmental clearance certificate for green category industries in Bangladesh. **(5)**

(b) Explain the purpose, function and organization of US Environmental Protection Agency. **(15)**

(c) Describe Senator Edward Muskie's influence on the creation of EPA. What were his ideas for characterising EPA? **(8)**

(d) Mention the basic objectives and key provisions of 'SAFE Drinking Water Act'. **(7)**

8. (a) What are the rationale and shortcomings of regulatory framework of USA? **(15)**

(b) What is environmental auditing? Explain auditing as a component of environmental management. **(15)**

(c) Write down the steps for conducting an IEE. **(5)**

Contd - - - P/3

TABLE 3(c)

Rainfall record for the Dismal Swamp (1 Oct. 1923–30 Sep. 1968)

	Number of storms of stated intensity or more										
	Intensity (mm/h)										
Duration (min)	20.0	30.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
5						245	49	16	7	3	2
10					256	64	15	7	4	1	
15				241	94	18	6	3	2		
20		240	80	36	10	4	2	1			
30	202	44	17	9	2	2	1				
40	76	31	8	1							
50	30	12	3								
60	9	2									

Q. 3(c)

TABLE 6-5
Key to stability categories

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

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

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

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

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

=5=

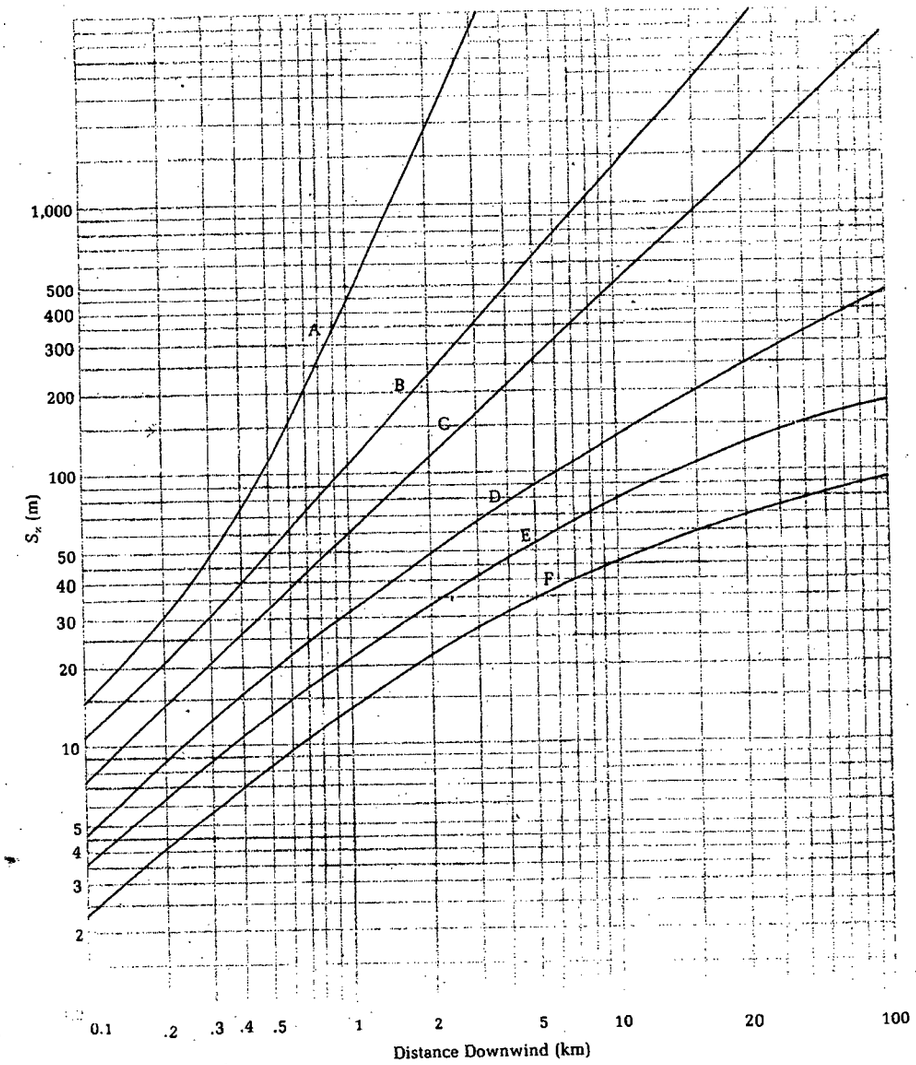

FIGURE 6-21
Vertical dispersion coefficient. (*Source:* Turner, *Workbook of Atmospheric Dispersion Estimates.*)

Q 2(c)

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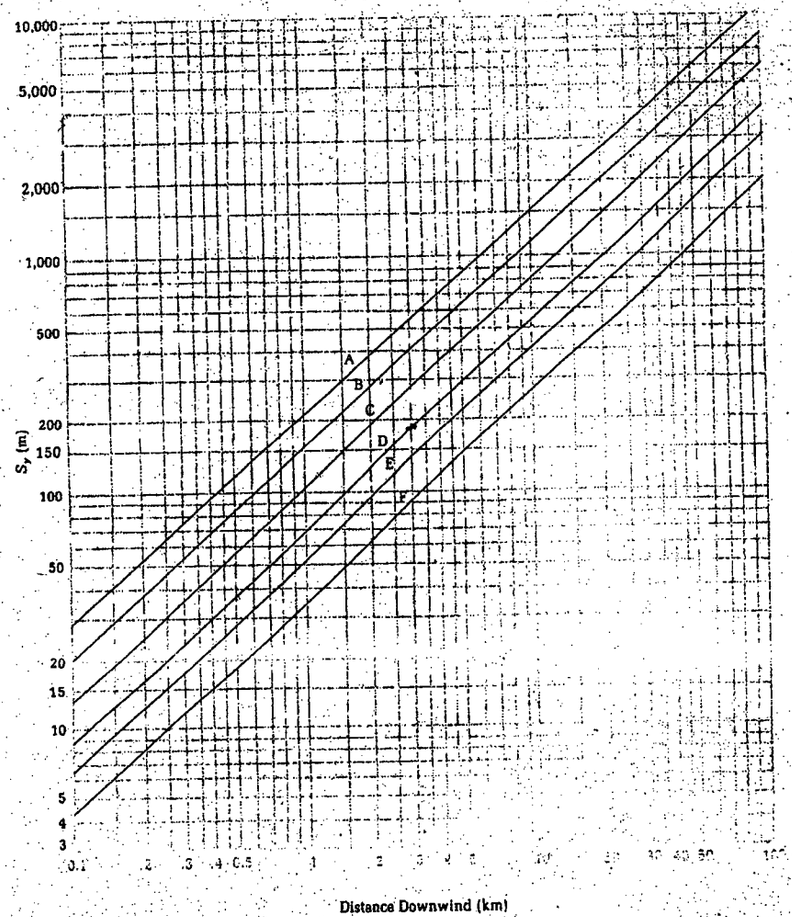

FIGURE 6-20
Horizontal dispersion coefficient. [*Source:* Turner, *Workbook of Atmospheric Dispersion Estimates* (U.S. Department of Health, Education and Welfare, Public Health Service, National Center for Air Pollution Control Publication No. 999-AP-28), Washington, DC: U.S. Government Printing Office,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