L-3/T-1/CHE **Date : 14/01/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 303** (Mass Transfer I)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

All plots used for calculation must be attached to the answer scripts.

1. (a) If a 40 mole% 2-propanol, 60 mole% water mixture at 60°C and 1 atm is heated at 85°C **(15)**

   (i) What fraction of the mixture will be vaporized? What is the composition of the vapor phase?

   (ii) What happens if the heating is repeated with a mixture containing 60 mole% 2-propanol and 40 mole% water? (VLE diagram attached).

   (b) A flash drum is to flash 1000 kmoles/hr of a feed that is 65 mole% benzene and 35 mole% toluene at 1 atm pressure. V/F = 0.4 (VLE diagram attached). **(20)**

   (i) Find $T_{drum}$, liquid mole fraction, vapor mole fraction

   (ii) Find the diameter and height required for a vertical flash drum

   Given, $\rho_L = 0.87$ gm/cc, $\rho_V = 0.00314$ gm/cc, $K_{drum} = 0.25$.

2. (a) For distillation at constant molal overflow, show the flow profiles schematically (plot L, V, $\overline{L}$, and $\overline{V}$ versus stage location) for **(10)**

   (i) Sub-cooled liquid feed

   (ii) Two phase feed

   (b) A distillation column is separating 1000 moles/hr of a 32 mole% ethanol, 68 mole% water mixture. The feed enters as a sub-cooled liquid that will condense one mole of vapor on the feed plate for every four moles of feed. The column has a total condenser and uses open steam heating. A distillate product $y_D = 0.75$ and a bottoms product $x_B = 0.1$ are desired. CMO is valid. The steam used is pure saturated water vapor. **(25)**

   (i) Find the minimum reflux ratio, $(L/D)_{min}$

   (ii) Use $L/D = 2\ (L/D)_{min}$ and find the number of equilibrium stages and optimum feed plate location.

   (iii) Find the steam flow rate used.

3. (a) When water is the more volatile component we do not need a condenser but can use direct cooling water as shown in Figure for Q. no. 3(a). We set $y_D = 0.92$, $x_B = 0.04$, $z = 0.4$ (all mole fractions water), feed is a saturated vapor, feed rate is 1000 kmoles/hr, P = 1 atm, CMO is valid, the entering cooling water (C) is a saturated liquid and is pure water ($x_c = 0$), and C/D = 3/4. Derive and plot the top operating line. Note that external balances (that is, balances around the entire column) are not required. **(17)**

Contd ..... P/2

## CHE 303

**Contd ... Q. No. 3**

(b) A distillation column is separating ethanol from water at a pressure of 1 kg/cm$^2$. A two-phase feed of 20 wt% ethanol at 93°C is input at 100 kg/min. The column has a total condenser and a partial reboiler. The distillate composition is 90 wt% ethanol. Distillate and reflux are at 20°C. Bottoms composition is 1 wt% ethanol. Reflux ratio is $L_0/D = 3$. Find $Q_C$ (condenser heat load) and $Q_R$ (reboiler heat load). (Enthalpy-composition diagram is attached). **(18)**

4. (a) What is Murphree efficiency, $E_{MV}$? Under what conditions $E_{MV} > 1$? **(10)**

(b) Draw the sieve tray performance diagram and label different regions. **(8)**

(c) Write down different ways of using an existing flash drum. **(10)**

(d) Show schematically different pressure heads on a sieve tray. **(7)**

### SECTION – B

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

All of the Figures should be attached with answer script.

5. (a) A solution of acetic acid (A) in water (D) is to be extracted using isopropyl ether as the solvent (S). The feed is 1000 kg/hr of a solution containing 35 wt% acid and 65 wt% water. The solvent is pure and it's flow rate is 1475 kg/hr. The existing raffinate stream should contains 10 wt% acetic acid. Find the outlet concentrations and the number of equilibrium stage required for this separation. The equilibrium data are given below. (Triangular diagram is attached). **(25)**

| Water Layer, wt% | | | Isopropyl Ether Layer, wt% | | |
|---|---|---|---|---|---|
| $x_A$ | $x_D$ | $x_S$ | $y_A$ | $y_D$ | $y_S$ |
| 0.69 | 98.1 | 1.2 | 0.18 | 0.5 | 99.3 |
| 1.41 | 97.1 | 1.5 | 0.37 | 0.7 | 98.9 |
| 2.89 | 95.5 | 1.6 | 0.79 | 0.8 | 98.4 |
| 6.42 | 91.7 | 1.9 | 1.93 | 1.0 | 97.1 |
| 13.30 | 84.4 | 2.3 | 4.82 | 1.9 | 93.3 |
| 25.50 | 71.1 | 3.4 | 11.40 | 3.9 | 84.7 |
| 36.70 | 58.9 | 4.4 | 21.60 | 6.9 | 71.5 |
| 44.30 | 45.1 | 10.6 | 31.10 | 10.8 | 58.1 |
| 46.40 | 37.1 | 16.5 | 36.20 | 15.1 | 48.7 |

Contd ..... P/3

## CHE 303

**Contd ... Q. No. 5**

(b) A water solution containing 0.005 mol fraction benzoic acid is to be extracted using pure benzene as the solvent. If the feed rate is 100 moles/hr and the solvent rate is 10 moles/hr find the number of equilibrium stages required to reduce the water concentration to 0.0001 mole fraction benzoic acid. Operation is isothermal at 6°C, where equilibrium data can be represented as: **(10)**

mole fraction of benzoic acid in water = 0.0446 × (mole fraction of benzoic acid in benzene)

6. A complete gas treatment plant often consists of both an absorber to remove the solute and a stripper to regenerate the solvent. Some of the treated gas is heated and used in the stripper. This is called stream B. In a particular application we wish to remove obnoxious impurity. A from the inlet gas. The absorber operates at 1.5 atm and 24°C where equilibrium is given as y = 0.5x (units are mole fractions). The stripper operates at 1 atm and 92°C where equilibrium is y = 3x (unit's are mole fractions). The total gas flow rate is 1400 moles/day, and the gas is 15 mole% A. The nonsoluble carrier is air. We desire a treated gas concentration of 0.5 mole% A. The liquid flow rate into the absorber is 800 moles/day and the liquid is 0.5 mole% A.

   (a) Write down the assumption needed to solve the problem of gas treatment plant. **(5)**

   (b) Calculate the number of stages in the absorber and the liquid concentration leaving. **(15)**

   (c) If the stripper is an already existing column with four equilibrium stage, calculate the gas flow rate of stream B (concentration is 0.5 mole% A) and the outlet gas concentration from the stripper. **(15)**

7. (a) Discuss the differences between batch and continuous distillation column. **(10)**

   (b) A one stage batch distillation column is used to distill a mixture of methanol and water at $L_0/D$ = 1.85. 1 kg mole of feed contains 57 mole% methanol. It is desired to final bottoms concentrations of methanol is 15 mole%. Find, $W_{final}$, D and $x_{D,avg}$ for this system. **(25)**

| x | 0 | 2 | 4 | 6 | 8 | 10 | 15 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| y | 0 | 13.4 | 23 | 30.4 | 36.5 | 41.8 | 51.7 | 57.9 | 66.5 | 72.9 | 77.9 | 82.5 | 87 | 91.5 | 95.8 | 100 |

8. (a) Starting from operating lines equation prove Kremser equation in the form of **(20)**

$$N = \frac{\ln\left[\left(1-\frac{mV}{L}\right)\left(\frac{y_{N+1}-y_1^*}{y_1-y_1^*}\right)+\frac{mV}{L}\right]}{\ln\left(L/mV\right)}$$

   (b) Write down the equilibrium relation and assumption for stage calculation of washing. **(7)**

   (c) Draw the cascade and McCabe-Thiele diagram for cross flow immiscible extraction. **(8)**

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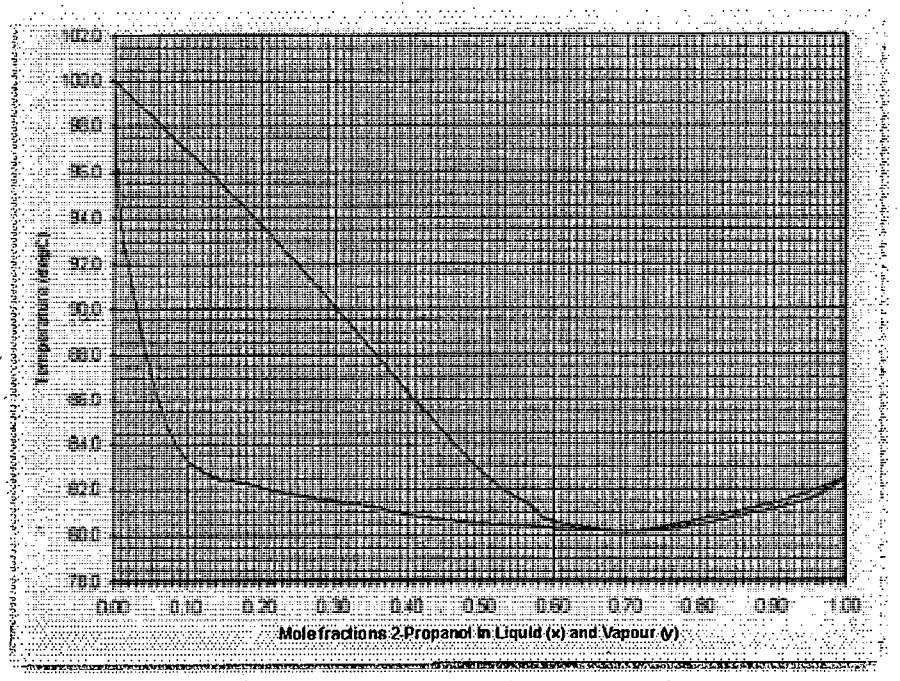



Figure for Question No. 1 a

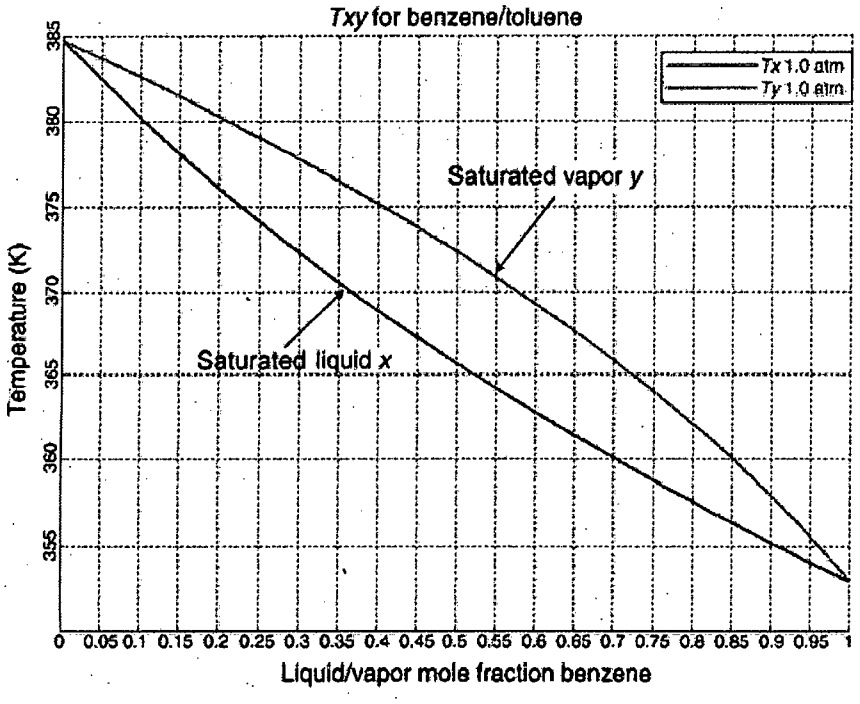


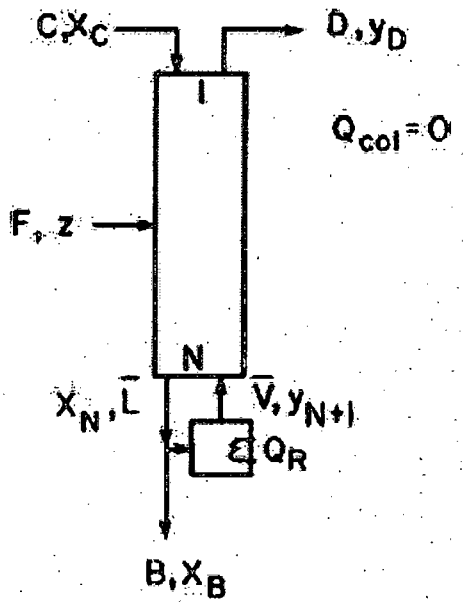

Figure for Question No. 1 b

Table for Question No. 2 b

Vapor Liquid equilibrium data for ethanol water

| Temperature | Mole percent ethanol in liquid | Mole percent ethanol in vapour |
|---|---|---|
| 100 | 0.00 | 0.00 |
| 95.5 | [illegible] | 17.00 |
| 89 | [illegible] | 38.91 |
| 86.7 | [illegible] | 43.75 |
| 85.3 | 12.33 | 47.04 |
| 84.15 | 16.61 | 50.09 |
| 82.7 | 23.37 | [illegible] |
| 82.3 | [illegible] | 55.80 |
| 81.5 | 32.73 | 58.26 |
| 80.7 | 39.65 | 61.22 |
| 79.8 | 50.00 | 65.64 |
| 79.7 | 51.98 | 65.99 |
| 79.3 | 57.32 | 68.41 |
| 78.7 | 67.63 | 73.85 |
| 78.4 | 74.72 | 76.15 |
| 78.15 | [illegible] | 89.43 |

Figure for Q No 3 a



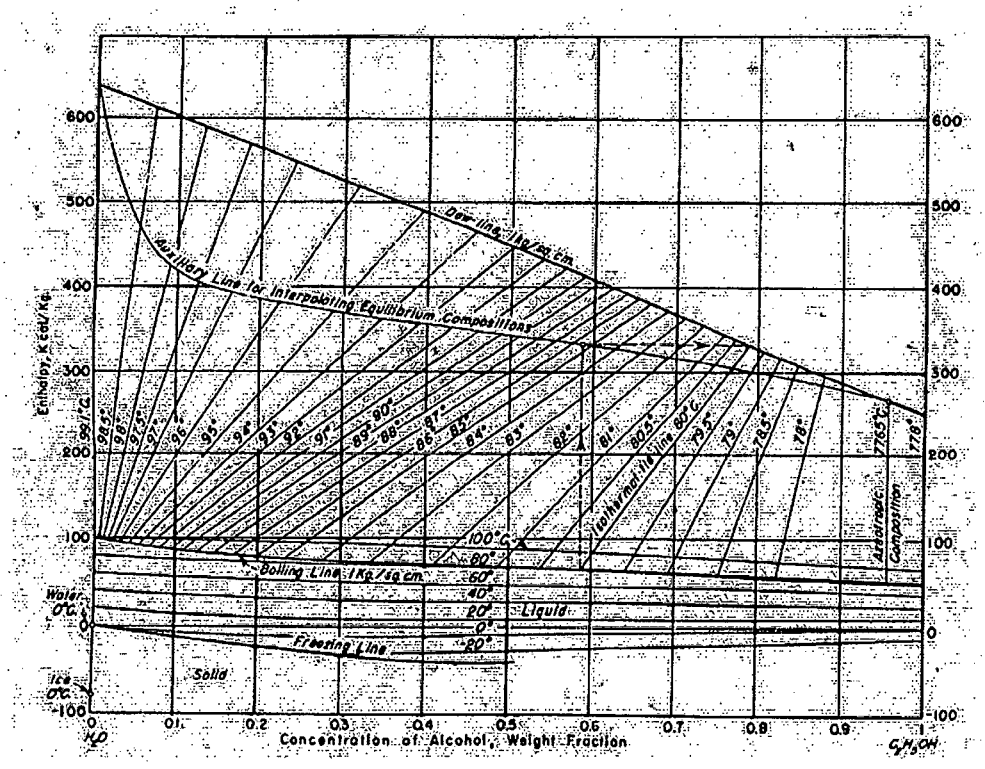
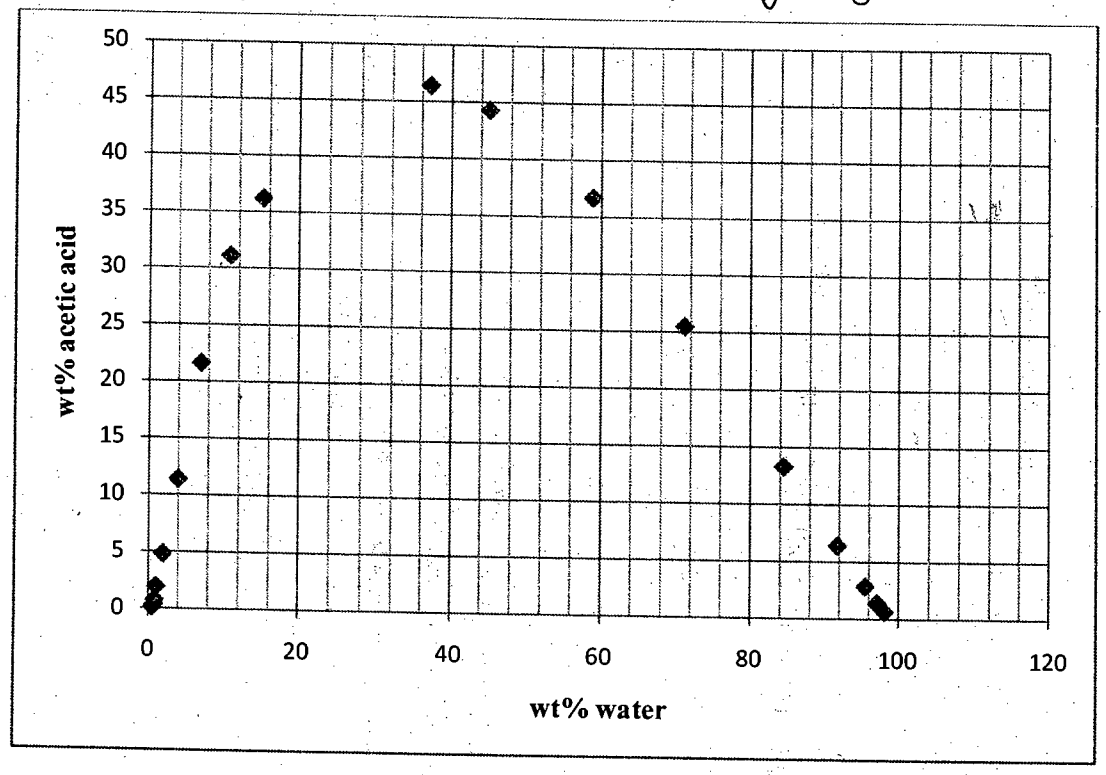




Figure for Q No 3 b

Enthalpy composition diagram of ethanol water at P = 1kg/cm$^2$

Triangular diagram for
Acetic acid - water - Isopropyl system.




For Question No 5-a

**L-3/T-1/CHE** **Date : 18/01/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **HUM 303** (Principles of Accounting)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) What are the elements of financial statements? Explain with examples. **(10)**

   (b) Mount View Motel has the following transaction on May, 2013: **(25)**

| | |
|---|---|
| May 1: | The Owner Investment Tk. 10,00,000 cash. |
| May 2: | Advertise on account Tk. 5000. |
| May 5: | Purchase supplies for cash Tk. 60,000. |
| May 10: | Purchased office equipment for Tk. 2,50,000, paying Tk. 50,000 in cash and remaining on account. |
| May 12: | Services provided on account Tk. 3,00,000. |
| May 15: | Withdraw cash for personal use Tk. 10,000. |
| May 18: | Salary for the month paid in cash Tk. 25,000. |
| May 20: | Paid balance due for advertisement. |
| May 22: | Cash received from customer for May 12 transaction. |
| May 24: | Provide services for cash Tk. 20,000. |

   **Required**:

   (i) Prepare necessary journal entries.

   (ii) Prepare a cash ledger account.

2. (a) What are the limitations of a trial balance? **(4)**

   (b) Following are the account balances of Butterfly Computer Service Limited for the year on 30th June, 2012: **(19)**

   Cost of computer Tk. 2,000,000; Sale of computer Tk. 34,00,000; Services fees received Tk. 3,00,000; Salaries to engineers Tk. 2,00,000; Advertisement expense Tk. 50,000; Office rent Tk. 60,000; Maintenance expense Tk. 1,30,000; Account payable Tk. 80,000; Tax payable Tk. 5,000; Bad debts Tk. 50,000; Prepaid Insurance Tk. 50,000; Office equipment Tk. 60,000; Salary to staff Tk. 85,000; Bank Balance Tk. 4,55,000; Unpaid salaries Tk. 5,000; Accounts receivable Tk. 6,00,000; Opening stock of computer Tk. 4,00,000; Furniture Tk. 2,50,000; Capital Tk. 6,00,000.

   **Required**: Prepare a trial balance on 30th June, 2012.

Contd ..... P/2

**HUM 303/CHE**

**Contd ... Q. No. 2**

(c) Selected comparative data for Zerox Product Company are presented below: **(12)**

| | 2014 | 2013 |
|---|---|---|
| Net Sales (all in Credit) | Tk. 7,50,000 | Tk. 7,20,000 |
| Cost of Goods Sold | 4,80,000 | 4,40,000 |
| Interest Expense | 7,000 | 5,000 |
| Net Income | 45,000 | 42,000 |
| Accounts Receivable | 1,20,000 | 1,00,000 |
| Inventory | 85,000 | 75,000 |
| Total Assets | 5,80,000 | 5,00,000 |
| Total Shareholders' Equity | 4,30,000 | 3,25,000 |

**Required**: Compute the following ratios for 2014.

(i) Profit Margin

(ii) Asset Turnover

(iii) Return on Assets

(iv) Return on Shareholders' Equity.

(v) Inventory Turnover

(vi) Accounts Receivable Turnover

3. (a) What is accrual basis of accounting? How is it related to adjusting entry? **(5)**

(b) The trial balance of LG Electronics at January 31, 2015 is given below: **(30)**

LG Electronics
Trial Balance
January 31, 2015

| Account Title | Debit (Tk.) | Credit (Tk.) |
|---|---|---|
| Cash | 12,800 | |
| Supplies | 2,500 | |
| Prepaid Insurance | 3,000 | |
| Office Equipment | 5,000 | |
| Note payable | | 5,000 |
| Account Payable | | 2,500 |
| Unearned revenue | | 1,200 |
| Capital | | 10,000 |
| Drawings | 500 | |
| Services revenue | | 10,000 |
| Salary expense | 4,000 | |
| Utility expense | 900 | |
| Total | 28,700 | 28,700 |

Contd ..... P/3

## HUM 303/CHE

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

Analysis reveals the following additional data:

- Supplies on hand at January 31, Tk. 1,200.
- Insurance policy is for two years.
- Depreciation Tk. 200 for each month.
- Unearned revenue in still unearned Tk. 800.
- Interest accrued at January Tk. 200.
- Service provided but not received Tk. 1,200.

**Required**:

(i) Prepare adjusting journal entries.

(ii) Prepare adjusted trial balance as on January 31, 2015.

4. The following is the trial balance of Trays Company as on 31st December, 2015. **(35)**

| Accounts Title | Debit (Tk.) | Credit (Tk.) |
|---|---|---|
| Sales Revenue | | 50,000 |
| Merchandise Inventory (01.01.11) | 6,000 | |
| Purchase | 24,000 | |
| Purchase Return | | 1,000 |
| Sales discounts | 2,500 | |
| Accounts Receivable | 20,000 | |
| Accounts Payable | | 14,000 |
| Capital | | 40,000 |
| Drawings | 10,000 | |
| Salaries | 8,000 | |
| Supplies | 3,000 | |
| Delivery Van | 20,000 | |
| Cash | 9,300 | |
| Prepaid Insurance | 2,200 | |
| Total | 105,000 | 105,000 |

Other Information:

(i) Supplies used Tk. 1,200.

(ii) Depreciation on delivery van is Tk. 2,000.

(iii) Merchandise Inventory (31.12.15) was Tk. 5,500.

(iv) Tk. 2500 of accounts receivable was uncollectible.

(v) Salaries were accrued Tk. 4,000.

(vi) Insurance expense was Tk. 2,000.

**Required**:

(a) Prepare a multiple step income statement and a owners equity statement.

(b) Prepare a classified Balance Sheet as on 31st December, 2015.

Contd ..... P/4

**HUM 303/CHE**

## SECTION – B

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

5. (a) "A variable cost is a cost that varies per unit of product, whereas a fixed cost is constant per unit of product." Do you agree? Explain. **(5)**

(b) Define the following cost concept with example (any four): **(8)**

(i) Non-manufacturing cost.

(ii) Relevant range.

(iii) Discretionary fixed cost.

(iv) Differential cost.

(v) Prime cost.

(c) The SUSAN Company makes art prints. The following details are available for the year ended 31st December, 2010. **(22)**

| SUSAN Company | |
|---|---|
| | Amount (Tk.) |
| **Opening stock**: | |
| Direct materials | 26,000 |
| Work-in-process | 74,000 |
| Finished goods | 120,000 |
| Direct material purchased | 436,000 |
| Direct labor | 12,000 |
| Indirect labor | 44,000 |
| Administrative expenses | 160,000 |
| Depreciation on factory equipment | 70,000 |
| Selling expenses | 140,000 |
| Factory power, heat and light | 20,000 |
| Building rent (production uses 80% of the spaces, administration and sales uses the rest) | 50,000 |
| Sales promotion | 10,000 |
| Sales | 1,000,000 |
| Utility, factory | 5,000 |
| **Closing stock**: | |
| Direct material | 42,000 |
| Work-in-process | 54,000 |
| Finished goods | 80,000 |

**Required**:

(i) Prepare a cost of goods sold statement.

(ii) Prepare an income statement.

Contd ..... P/5

**HUM 303/CHE**

6. (a) What is meant by degree of operating leverage? Why is it calculated? **(3)**

(b) Quality Products manufactures plastic football. The **selling price** is Tk. 37.50 per unit and **variable cost** is Tk. 22.50 per unit. Over the past company **sold 40,000 units** of football, with the following results: **(20)**

| | |
|---|---|
| Sales | Tk. 1,500,000 |
| Less: variable expense | Tk. 900,000 |
| Contribution margin | Tk. 600,000 |
| Less: fixed expense | Tk. 480,000 |
| Net operating income | Tk. 120,000 |

**Required**:

(i) Compute CM ratio and break even points in units and in amounts. Also compute degree of operating leverage of sales.

(ii) The company estimates that, in the next year variable cost will increase by Tk. 3 per football. The selling price will remain constant at Tk. 37.50 per football. What will be the new CM ratio and the new break even points in units and amounts?

(iii) Refer to the data (ii) above if the expected change in variable costs take place how many footballs will have to be sold to earn the same net operating income (Tk. 120,000) as last year?

(iv) Refer to the original data, assume that if variable cost will decreases by 40% but fixed cost will increase by 90%. What should be the new CM ratio and break even points in units and amounts?

(v) Refer to the (iv) above, assume that in next year company will sell 50,000 units of football. Compute – Contribution margin format income statement and margin of safety in units.

(c) Speedy parcel service operates a fleet of delivery trucks in a large metropolitan area. A cost analyst has determined that if a truck is driven 120,000 miles during a year, the average operating cost is Tk. 11.6 per mile. If a truck is driven only 80,000 miles during a year, the average operating cost increases to Tk. 13.6 per mile. **(12)**

**Required**:

(i) Using high-low method, estimates the variable and fixed cost elements of the annual cost of truck operation.

(ii) Express the variable and fixed costs in the form of $Y = a + bX$.

(iii) If a truck were driven 100,000 miles during a year, what total cost would you expect to be incurred?

Contd ..... P/6

**HUM 303/CHE**

7. (a) Explain how fixed manufacturing overhead costs are shifted from one period to another under absorption costing system? **(5)**

(ii) (a) "Aqua guard Company" manufactures and sells single product. You have been given the following information – **(30)**

| Particulars | Amounts (Tk.) |
|---|---|
| **Variable cost per unit:** | |
| Direct materials | 18 |
| Direct labor | 7 |
| Variable manufacturing overhead | 2 |
| Variable selling and administrative expenses | 5 |
| **Fixed cost per year:** | |
| Fixed manufacturing overhead | 160,000 |
| Fixed selling and administrative expenses | 110,000 |

During the year, the company produced 20,000 units and sold Tk. 16,000 units. The selling price of per unit is Tk. 50.

**Required**:

(i) Calculate the product cost per unit under absorption costing system and variable costing system.

(ii) Prepare income statement using under absorption costing system and variable costing system.

(iii) Reconcile the amount of profits under two costing systems.

8. (a) Write down the criteria for cost allocation. **(5)**

(b) "Toshiba Company" provides outsourcing and consulting services to government and corporate clients. It has two supports departments – Human Resource (HR) and Information Technology (IT) – and two operating departments – Government Consulting (GOVT) and Corporate Consulting (CORP). For the year 2015, the following information were available. **(15)**

| | Support Dept. | | Operating Dept. | | Total |
|---|---|---|---|---|---|
| | HR | IT | GOVT | CORP | |
| Budgeted overhead before allocation (Tk.) | 600,000 | 24,00,000 | 87,56,000 | 124,52,000 | 242,08,000 |
| Support work by HR | --- | 25% | 40% | 35% | 100% |
| Support work by IT | 10% | --- | 30% | 60% | 100% |

Contd ..... P/7

## HUM 303/CHE

**Contd ... Q. No. 8(b)**

**Required**:

Allocate two supports departments cost to the two operating departments by using –

(i) Direct method.

(ii) Step-down method.

(iii) Reciprocal method.

(c) A company wants to purchase a new equipment. The related information of the equipment is as follows: **(15)**

| Cost of the equipment | Tk. 70,000 |
|---|---|
| **Year** | **Net Profit After Tax (NPAT)** |
| 1 | Tk. 40,000 |
| 2 | 13,000 |
| 3 | 20,000 |
| 4 | 10,000 |
| 5 | 7,000 |

**Required**: Calculate

(i) Pay Back Period (PBP).

(ii) Internal rate of return (IRR).

(iii) Net Present Value (NPV) at 10% cost of capital.

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L-3/T-1/CHE Date : 24/01/2017

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 301** (Heat Transfer)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FOUR** questions in this section. **Q. No. 1** is **COMPULSORY** and carries 45 marks. Answer any **TWO** from the rest.

1. **(COMPULSORY)** (a) 20,160 lb/hr of a 30% $K_3PO_4$ solution is to be cooled from 150 to 90°F using well water from 68 to 90°F. Pressure drops of 10 psi are allowable on both streams, and a total dirt factor of 0.002 is required. A 1-2 shell and tube heat exchanger is being used for this process.

| Shell Side | Tube Side |
|---|---|
| ID = 10.02 in. | BWG 16 |
| Baffle spacing = 2 inch | Tube no = 52; Tube length = 16 ft |
| $a_s = 0.0347\ ft^2$ | Tube OD = 0.75 inch; Tube ID = 0.62 inch |
| | Pitch = 1 inch square |

Physical properties at caloric temperature:

**Phosphate solution**:

(i) Viscosity = 2.90 lb/ft.hr

(ii) Thermal Conductivity = 0.33 Btu/hr.ft.°F

(iii) Specific Heat Capacity = 0.757 Btu/lb°F

**Water**:

(i) Viscosity = 2.20 lb/ft.hr

(ii) Thermal Conductivity = 0.386 Btu/hr.ft.°F

(iii) Specific Heat Capacity = 1.0 Btu/lb°F

(a) Draw a temperature profile along the heat exchanger length, and find the log mean temperature difference. **(5)**

(b) Which liquid would you place in the tube side and why? **(3)**

(c) Determine the tube side and shell side heat transfer coefficients, $h_i$ and $h_o$, respectively. **(14)**

(d) Find the clean overall coefficient for the exchanger? **(4)**

(e) Calculate Design Overall Coefficient. Perform all the necessary calculations and check if the exchanger is suitable for use. **(12)**

(f) Fill in the attached TEMA sheet and attach it to your answer script. **(7)**

Contd ..... P/2

**CHE 301**

2. (a) What is Leidenfrost point? With the help of a neat sketch of pool boiling curve discuss the main regimes of the curve. **(15)**

   (b) Water is to be boiled at atmospheric pressure on a 3-cm-diameter mechanically polished steel heater. Determine the maximum heat flux that can be attained in the nucleate boiling regime and the temperature at which burnout will occur. **(15)**

   At 100°C:

   $\rho_v = 0.6$ kg/m$^3$; $\sigma = 0.0589$ N/m and $h_{fg} = 2257 \times 10^3$ J/kg

3. (a) The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of 12 horizontal tubes (arranged in a rectangular array of 3 tubes high and 4 tubes wide) through which cooling water circulates. The outer diameter of the pipes is 3 cm, and the outer surfaces of the pipes are maintained at 30°C. Determine (a) the rate of heat transfer to the cooling water circulating in the pipes and (b) the rate of condensation of steam per unit length of a horizontal pipe. **(15)**

   The properties of water at the saturation temperature of 40°C corresponding to 7.38 kPa are $h_{fg} = 2407 \times 10^3$ J/kg and $\rho_v = 0.05$ kg/m$^3$.

   (b) What is the significance of Grashof number in Natural convection? A fine wire having a diameter of 0.02 mm is maintained at a constant temperature of 54°C by an electric current. The wire is exposed to air at 1 atm and 0°C. Calculate the electric power necessary to maintain the wire temperature if the length is 50 cm. **(15)**

4. (a) Why counter flow is preferred than parallel flow? Explain. **(6)**

   (b) Calculate equivalent diameter for square pitch and triangular pitch tube arrangement of a shell and tube heat exchanger where tube OD is 0.75 inch and the clearance is 0.25 inch. **(10)**

   (c) List some factors that should be considered during selection of fluid for shell and tube side. **(6)**

   (d) What are the two equivalent diameters used in heat exchanger calculations? Explain the differences with examples. **(8)**

## SECTION – B

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

5. (a) Starting from the Fourier's law of heat conduction, develop the general three-dimensional heat-conduction equation. **(14)**

   (b) Derive an expression for the heat flow from a hollow sphere. The inside and outside surfaces of the hollow sphere are maintained at $T_i$ and $T_o$ temperatures respectively. **(16)**

   (c) Write a few words on "thermal contact resistance". **(5)**

Contd ..... P/3

## CHE 301

6. (a) Discuss the phenomenon called "critical insulation thickness". Derive the equation for critical insulation thickness for a pipe. **(5+8)**

   (b) Steam at 320°C flows in a cast iron pipe (k = 80 W/m.°C) whose inner and outer diameters are 5 cm and 5.5 cm, respectively. The pipe is covered with 3-cm thick wool insulation with k = 0.05 W/m.°C. Heat is lost to the surroundings at 5°C by natural convection and radiation, with a combined heat transfer coefficient of 18 $W/m^2.°C$. Taking the heat transfer coefficient inside the pipe to be 60 $W/m^2.°C$, determine the rate of heat loss from the steam per unit length of the pipe. Also determine the temperature drops across the pipe shell and the insulation. **(22)**

7. (a) An incompressible fluid is flowing past a smooth flat plate. Starting from the continuity and momentum equations for the system, show that approximate thickness of the boundary layer is given by: **(22)**

$$\delta = 4.64\sqrt{\frac{vx}{u_\alpha}}$$

   The notations have their usual meanings. Continuity and momentum equations for the system are given in "Notes for Q. 7(a)."

   (b) Atmospheric air at 300 K flows over a flat plate at a speed of 2 m/s. If the viscosity of air at 300 K is $1.85 \times 10^{-5}$ kg/m.s, calculate the boundary layer thickness at distances of 20 cm and 40 cm from the leading edge of the plate. **(13)**

8. (a) Derive the relation known as Reynolds-Colburn analogy. Write a few words on its applicability. **(11)**

   (b) Write the equation known as Dittus-Boelter equation. Write its applicability ranges. Write few modifications of this equation as suggested by different researchers. **(11)**

   (c) We know that the laminar velocity profile in a tube is parabolic. For heating or cooling, this parabolic velocity profile is changed to some extent. Draw few of those profiles. **(5)**

   (d) Explain the physical significances of Nusselt and Prandtl numbers. **(8)**

---

**Notes for Q. 7 (a)**

For incompressible fluid flow past a smooth flat plate:

Continuity equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

Momentum equation

$$\rho\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = \mu\frac{\partial^2 u}{\partial y^2} - \frac{\partial p}{\partial x}$$

Energy equation

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} + \frac{\mu}{\rho C_p}\left(\frac{\partial u}{\partial y}\right)^2$$

**Relevant Equations:**

$$\mathrm{Gr}_x = \frac{g\beta(T_w - T_\infty)x^3}{\nu^2}$$

$$\overline{Nu} = CRa^m$$

$$\dot{q}_{\max} = C_{cr}\, h_{fg}[\sigma g \rho_v^2\, (\rho_l - \rho_v)]^{1/4}$$

$$\dot{q}_{\text{nucleate}} = \mu_l\, h_{fg}\left[\frac{g(\rho_l - \rho_v)}{\sigma}\right]^{1/2}\left[\frac{C_p(T_s - T_{\text{sat}})}{C_{sf}\, h_{fg}\, \mathrm{Pr}_l^n}\right]^3$$

$$h_{\text{horizontal}} = 0.729\left[\frac{g\rho_l\,(\rho_l - \rho_v)\; h_{fg}^*\, k_l^3}{\mu(T_{\text{sat}} - T_s)\; D}\right]^{1/4}$$

**Table:** Values of the coefficient $C_{sf}$ and $n$ for various fluid-surface combinations

| Fluid-Heating Surface Combination | $C_{sf}$ | $n$ |
|---|---|---|
| Water–copper (polished) | 0.0130 | 1.0 |
| Water–copper (scored) | 0.0068 | 1.0 |
| Water–stainless steel (mechanically polished) | 0.0130 | 1.0 |
| Water–stainless steel (ground and polished) | 0.0060 | 1.0 |
| Water–stainless steel (teflon pitted) | 0.0058 | 1.0 |
| Water–stainless steel (chemically etched) | 0.0130 | 1.0 |
| Water–brass | 0.0060 | 1.0 |
| Water–nickel | 0.0060 | 1.0 |
| Water–platinum | 0.0130 | 1.0 |
| *n*-Pentane–copper (polished) | 0.0154 | 1.7 |
| *n*-Pentane–chromium | 0.0150 | 1.7 |
| Benzene–chromium | 0.1010 | 1.7 |
| Ethyl alcohol–chromium | 0.0027 | 1.7 |
| Carbon tetrachloride–copper | 0.0130 | 1.7 |
| Isopropanol–copper | 0.0025 | 1.7 |

**Table:** Values of the coefficient $C_{cr}$ for use in Equation for maximum heat flux

| Heater Geometry | $C_{cr}$ | Charac. Dimension of Heater, $L$ | Range of $L^*$ |
|---|---|---|---|
| Large horizontal flat heater | 0.149 | Width or diameter | $L^* > 27$ |
| Small horizontal flat heater[1] | $18.9K_1$ | Width or diameter | $9 < L^* < 20$ |
| Large horizontal cylinder | 0.12 | Radius | $L^* > 1.2$ |
| Small horizontal cylinder | $0.12L^{*-0.25}$ | Radius | $0.15 < L^* < 1.2$ |
| Large sphere | 0.11 | Radius | $L^* > 4.26$ |
| Small sphere | $0.227L^{*-0.5}$ | Radius | $0.15 < L^* < 4.26$ |

[1] $K_1 = \sigma/[g(\rho_l - \rho_v)A_{heater}]$

**Table:** Constants for use with the equation for isothermal surface to calculate Nusselt number during natural convection

| Geometry | $Gr_f Pr_f$ | $C$ | $m$ | Reference(s) |
|---|---|---|---|---|
| Vertical planes and cylinders | $10^{-1}$–$10^4$ | Use Fig. 7-5 | Use Fig. 7-5 | 4 |
| | $10^4$–$10^9$ | 0.59 | $\frac{1}{4}$ | 4 |
| | $10^9$–$10^{13}$ | 0.021 | $\frac{2}{5}$ | 30 |
| Horizontal cylinders | $10^9$–$10^{13}$ | 0.10 | $\frac{1}{3}$ | 22, 16† |
| | 0–$10^{-5}$ | 0.4 | 0 | 4 |
| | $10^{-5}$–$10^4$ | Use Fig. 7-6 | Use Fig. 7-6 | 4 |
| | $10^4$–$10^9$ | 0.53 | $\frac{1}{4}$ | 4 |
| | $10^9$–$10^{12}$ | 0.13 | $\frac{1}{3}$ | 4 |
| | $10^{-10}$–$10^{-2}$ | 0.675 | 0.058 | 76† |
| | $10^{-2}$–$10^2$ | 1.02 | 0.148 | 76† |
| | $10^2$–$10^4$ | 0.850 | 0.188 | 76 |
| | $10^4$–$10^7$ | 0.480 | $\frac{1}{4}$ | 76 |
| | $10^7$–$10^{12}$ | 0.125 | $\frac{1}{3}$ | 76 |
| Upper surface of heated plates or lower surface of cooled plates | $2 \times 10^4$–$8 \times 10^6$ | 0.54 | $\frac{1}{4}$ | 44, 52 |
| Upper surface of heated plates or lower surface of cooled plates | $8 \times 10^6$–$10^{11}$ | 0.15 | $\frac{1}{3}$ | 44, 52 |
| Lower surface of heated plates or upper surface of cooled plates | $10^5$–$10^{11}$ | 0.27 | $\frac{1}{4}$ | 44, 37, 75 |
| Vertical cylinder, height = diameter characteristic length = diameter | $10^4$–$10^6$ | 0.775 | 0.21 | 77 |
| Irregular solids, characteristic length = distance fluid particle travels in boundary layer | $10^4$–$10^9$ | 0.52 | $\frac{1}{4}$ | 78 |

† Preferred.

## Heat Exchanger Specification Sheet

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Company: | | | | | | | |
| 2 | Location: | | | | | | | |
| 3 | Service of Unit: | | Our Reference: | | | | | |
| 4 | Item No.: | | Your Reference: | | | | | |
| 5 | Date: | Rev No.: | Job No.: | | | | | |
| 6 | Size / | in | Type | Connected in | parallel | series | | |
| 7 | Surf/unit(eff.) | ft2 | Shells/unit | Surf/shell (eff.) | ft2 | | | |
| 8 | **PERFORMANCE OF ONE UNIT** | | | | | | | |
| 9 | Fluid allocation | | | **Shell Side** | | **Tube Side** | | |
| 10 | Fluid name | | | | | | | |
| 11 | Fluid quantity, Total | | lb/h | | | | | |
| 12 | Vapor (In/Out) | | lb/h | | | | | |
| 13 | Liquid | | lb/h | | | | | |
| 14 | Noncondensable | | kg/s | | | | | |
| 15 | | | | | | | | |
| 16 | Temperature (In/Out) | | F | | | | | |
| 17 | Dew / Bubble point | | F | | | | | |
| 18 | Density | | lb/ft3 | | | | | |
| 19 | Viscosity | | cp | | | | | |
| 20 | Molecular wt, Vap | | | | | | | |
| 21 | Molecular wt, NC | | | | | | | |
| 22 | Specific heat | | BTU/(lb*F) | | | | | |
| 23 | Thermal conductivity | | BTU/(ft*h*F) | | | | | |
| 24 | Latent heat | | BTU/lb | | | | | |
| 25 | Pressure | | psi | | | | | |
| 26 | Velocity | | ft/s | | | | | |
| 27 | Pressure drop, allow./calc. | | psi | | | | | |
| 28 | Fouling resist. (min) | | ft2*h*F/BTU | | | | | |
| 29 | Heat exchanged | BTU/h | | MTD corrected | F | | | |
| 30 | Transfer rate, Service | | Dirty | Clean | BTU/(h*ft2*F) | | | |
| 31 | **CONSTRUCTION OF ONE SHELL** | | | | | **Sketch** | | |
| 32 | | | **Shell Side** | **Tube Side** | | | | |
| 33 | Design/Test pressure | psi | / Code | / Code | | | | |
| 34 | Design temperature | F | | | | | | |
| 35 | Number passes per shell | | | | | | | |
| 36 | Corrosion allowance | in | | | | | | |
| 37 | Connections | In | / | / | | | | |
| 38 | Size/rating | Out | / | / | | | | |
| 39 | in | Intermediate | / | / | | | | |
| 40 | Tube No. | OD | Tks-avg | in | Lengh | ft | Pitch | in |
| 41 | Tube type | | Material | | Tube pattern | | | |
| 42 | Shell | ID | OD | in | Shell cover | | | |
| 43 | Channel or bonnet | | | | Channel cover | | | |
| 44 | Tubesheet-stationary | | | | Tubesheet-floating | | | |
| 45 | Floating head cover | | | | Impingement protection | | | |
| 46 | Baffle-crossing | Type | single seg | Cut(%d) | hor | Spacing: c/c | in | |
| 47 | Baffle-long | | Seal type | | Inlet | in | | |
| 48 | Supports-tube | | U-bend | | Type | | | |
| 49 | Bypass seal | | Tube-tubesheet joint | | | | | |
| 50 | Expansion joint | | Type | | | | | |
| 51 | RhoV2-Inlet nozzle | Bundle entrance | | Bundle exit | lb/(ft*s2) | | | |
| 52 | Gaskets - Shell side | | Tube Side | | | | | |
| 53 | Floating head | | | | | | | |
| 54 | Code requirements | | | TEMA class | | | | |
| 55 | Weight/Shell | Filled with water | | Bundle | lb | | | |
| 56 | Remarks | | | | | | | |
| 57 | | | | | | | | |
| 58 | | | | | | | | |

L-3/T-1/CHE **Date : 29/01/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **MATH 323** (Fourier Analysis, Harmonic Functions and Partial Differential Equations)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Explain Fourier series representation of a function f($x$) over the interval $-L \le x \le L$. Write down the Dirichlet conditions. Expand f($x$) = $x$, $0 < x < 2$, in a half range (i) sine series, (ii) cosine series. **(17)**

   (b) (i) Find the Fourier coefficients corresponding to the function: **(10)**

   $$F(x) = \begin{cases} 0 \ , & \text{for } -5 < x < 0 \\ 3 \ , & \text{for } 0 < x < 5 \end{cases} ; \quad \text{Period} = 10$$

   Write down the corresponding Fourier series.

   (ii) How should F($x$) be defined at $x = -5$, $x = 0$ and $x = 5$ in order that the Fourier series will converge to $F(x)$ for $-5 \le x \le 5$? **(8)**

2. (a) Sketch the even extension of the function f($x$) = $\sin x$, $0 < x < \pi$ and then expand in a Fourier cosine series. **(17)**

   (b) Find the (i) finite Fourier sine transform and (ii) finite Fourier cosine transform of the function f($x$) = $2x$, $0 < x < 4$. Then write down the corresponding Fourier series. **(18)**

3. (a) U is a function of $x$ and t for $0 < x < L$, $t > 0$. **(15)**

   Calculate $F_s\left\{\frac{\partial U}{\partial x}\right\}$, $F_c\left\{\frac{\partial U}{\partial x}\right\}$, $F_s\left\{\frac{\partial^2 U}{\partial x^2}\right\}$ and $F_c\left\{\frac{\partial^2 U}{\partial x^2}\right\}$

   (b) Use finite Fourier transform to solve $\frac{\partial U}{\partial t} = 2\frac{\partial^2 U}{\partial x^2}$, $0 < x < 4$, $t > 0$, $U(0, t) = 0$, $U(4, t) = 0$, $U(x, 0) = 3 \sin \pi x - 2 \sin 5\pi x$. Give a physical interpretation of the solution. **(20)**

4. Find the Fourier transform of the function $F(x) = \begin{cases} 1 \ , & \text{for } |x| < a \\ 0 \ , & \text{for } |x| > a \end{cases}$;

   Graph $F(x)$ and its Fourier transform for $a = 3$.

   Use the above result to evaluate $\int_{-\infty}^{\infty} \frac{\sin \lambda a \cos \lambda x}{\lambda} d\lambda$ and hence find the value of $\int_0^{\infty} \frac{\sin u}{u} du$. **(35)**

Contd ..... P/2

# MATH 323

## SECTION – B

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

5. (a) Form a PDE by eliminating the arbitrary function $f$ from the equation $z = e^{mx} f(x + y)$. **(10)**

(b) Solve the following PDEs:

(i) $x^2 (y - z)p + y^2 (z - x)q = z^2 (x - y)$ **(12)**

(ii) $z - px - qy = p^2 + q^2$ **(13)**

6. (a) Find the integral surface of the equation $(x - y)p + (y - x - z)q = z$ which contains the circle $z = 1, x^2 + y^2 = 1$. **(13)**

(b) Solve the following:

(i) $\left(D_x^3 + 4D_x^2 D_y + 4D_x D_y^2\right) z = 4 \sin (2x + y)$ **(11)**

(ii) $(D_x - D_y - 1)(D_x - D_y - 2)z = e^{2x - y} + x$ **(11)**

7. (a) Solve Laplace's equation $\nabla^2 v = 0$ in polar coordinates $(r, \theta)$. **(18)**

(b) Find the temperature for a steady flow of heat in a semicircular plate of radius r. The circumference is kept at a temperature $v_\theta$ and the diameter at a temperature zero. **(17)**

8. (a) Find the potential about a spherical surface. **(18)**

(b) A long rectangular plate of width 'a' cm with insulated surfaces has its temperature $\phi$ equal to zero on both the long sides and one of the short sides so that **(17)**

$$v(0, y) = 0, \quad v(a, y) = 0,$$
$$v(x, 0) = kx, \quad v(x, \infty) = 0$$

Find the steady-state temperature $v(x, y)$ within the plate.

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L-3/T-1/CHE Date : 29/01/2017

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 471** (Biochemistry)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) What are two unusual properties of water and what is(are) the factor(s) that contribute to these properties? **(10)**

   (b) Explain how amphipathic molecules interact with water and explain the resultant solubility in terms of changes in entropy. **(12)**

   (c) Calculate the percentage change in pH when 1.0 ml of 2M HCI is added to 50 mL of 0.2 M phosphate buffer at pH 7.2. Phosphoric acid is tribasic, with pKa's of 2.14, 6.86 and 12.4. **(13)**

2. (a) What are the differences between primary database and derived database? **(8)**

   (b) With the help of schematic diagrams describe the salient features of a DNA double helix. **(7)**

   (c)Give a few examples of commonly found secondary structures in RNA strands? Explain why they are formed. **(5)**

   (d) Given the following DNA template sequence write down the corresponding DNA coding strand and the corresponding mRNA sequence. Finally write down the sequence of amino acids that are coded by the sequence given using the chart given below. Choose the correct reading frame based on the start codon DNA TEMPLATE sequence. **(15)**

   5' ATGCCCCTTAAAGAGTTTACATATGCTGGACAT 3'

3. Match the following amino acids to their correct properties, elaborating the reason behind your choice of property. (One property for each amino acid). **(7×5=35)**

   For the following amino acids (i-vii) draw the structures, write down the three letter code and one letter code.

| **Amino Acid** | **Property** |
|---|---|
| (i) Alanine | (i) Hydropathy index of +3.8 |
| (ii) Histidine | (ii) Hydropathy index of –3.8 |
| (iii) Lysine | (iii) Causes instability in α helices |
| (iv) Leucine | (iv) Common amino acid found in β pleats |
| (v) Proline | (v) Sugars attach to form glycolproteins |
| (vi) Methionine | (vi) Encoded by the start codon |
| (vii) Threonine | (vii) Has buffering properties at biological pH |

Contd ..... P/2

**CHE 471**

4. (a) Draw the fully protonated structure and the titration curve for the pentapeptide CLEAN. Mark on the titration curve the net charge on this tetrapeptide at various pHs. What is the pI and the molecular weight of this tetrapeptide? **(15)**

(b) Explain what you understand by the following statements, with appropriate schematics/diagrams (any five) **(4×5=20)**

(i) Peptide bond has a double bond character

(ii) The α-helix has an overall dipole moment

(iii) Replication tends to occur bidirectionally

(iv) pKa values for the ionizable groups in glycine are lower than those for simple, methyl-substituted amino and carboxylgroups.

(v) The enzyme DNA polymerase catalyzes the addition of dNTP to a DNA chain.

(vi) Beer Lambert law can be used to detect purity of genetic material.

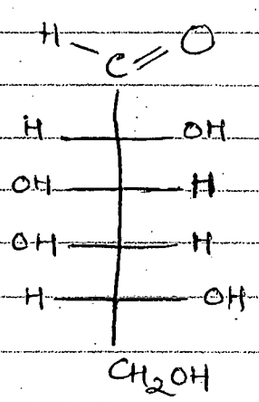
## SECTION – B

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

5. (a) What are the reaction rates and reaction equilibria? Which one is more important for enzyme activity? Explain. **(23)**

(b) The structure of D-galactose is attached below. Transform into cyclic form. Draw the C-4 epimer of D-galactose? **(9)**

Figure for Q 5(b)




(c) What are the functions of carbohydrates? **(3)**

6. (a) How cell organelles can be separated? **(15)**

(b) Write short notes on Mitochondria and chloroplast. **(10)**

(c) Describe amylase and amylopectin. **(10)**

## CHE 471

7. (a) The substrate concentration and velocity of an enzymatic reaction is given below. Determine $V_{max}$ and $k_m$. **(15)**

| [S] (m) | $V_0$ (μM/min) |
|---|---|
| 2.5 | 28 |
| 4 | 40 |
| 100 | 70 |
| 200 | 95 |
| 400 | 112 |
| 1000 | 128 |
| 20000 | 139 |
| 100000 | 140 |

(b) Describe the lock and key hypothesis of enzymatic activity, and explain the limitation of this hypothesis. **(15)**

(c) Write down a short notes on Molisch test. **(5)**

8. (a) Briefly describe the seven steps involved in protein sequencing. **(20)**

(b) Describe the basis of separation of different column chromatographic techniques. **(5)**

(c) Write down the uses of Gel electrophoresis and DNA Hybridization. **(10)**

---

**CHART : Amino acid properties**

| Amino acid name | Molecular weight of amino acid | Molecular weight of amino acid residue | pK of α-COOH group $pK_1$ | pK of α-$NH_3$ group $pK_2$ | pK of ionizing side chain $pK_R$ |
|---|---|---|---|---|---|
| Alanine | 89.10 | 71.08 | 2.34 | 9.69 | -- |
| Arginine | 174.20 | 156.18 | 2.17 | 9.04 | 12.48 |
| Asparagine | 132.12 | 114.10 | 2.02 | 8.80 | -- |
| Aspartic Acid | 133.11 | 115.09 | 1.88 | 9.60 | 3.65 |
| Cysteine | 121.16 | 103.14 | 1.96 | 10.28 | 8.18 |
| Glutamic Acid | 147.13 | 129.11 | 2.19 | 9.67 | 4.25 |
| Glutamine | 146.15 | 128.13 | 2.17 | 9.13 | -- |
| Glycine | 75.07 | 57.05 | 2.34 | 9.60 | -- |
| Histidine | 155.16 | 137.14 | 1.82 | 9.17 | 6.00 |
| Hydroxyproline | 131.13 | 113.11 | 1.82 | 9.65 | -- |
| Isoleucine | 131.18 | 113.16 | 2.36 | 9.60 | -- |
| Leucine | 131.18 | 113.16 | 2.36 | 9.60 | -- |
| Lysine | 146.19 | 128.17 | 2.18 | 8.95 | 10.53 |
| Methionine | 149.21 | 131.19 | 2.28 | 9.21 | -- |
| Phenylalanine | 165.19 | 147.17 | 1.83 | 9.13 | -- |
| Proline | 115.13 | 97.11 | 1.99 | 10.60 | -- |
| Serine | 105.09 | 87.07 | 2.21 | 9.15 | -- |
| Threonine | 119.12 | 101.10 | 2.09 | 9.10 | -- |
| Tryptophan | 204.23 | 186.21 | 2.83 | 9.39 | -- |
| Tyrosine | 181.19 | 163.17 | 2.20 | 9.11 | 10.07 |
| Valine | 117.15 | 99.13 | 2.32 | 9.62 | -- |

| First Base | Second Base: U | Second Base: C | Second Base: A | Second Base: G | Third Base |
|---|---|---|---|---|---|
| U | Phe | Ser | Tyr | Cys | U |
| | Phe | Ser | Tyr | Cys | C |
| | Leu | Ser | Stop | Stop | A |
| | Leu | Ser | Stop | Trp | G |
| C | Leu | Pro | His | Arg | U |
| | Leu | Pro | His | Arg | C |
| | Leu | Pro | Gln | Arg | A |
| | Leu | Pro | Gln | Arg | G |
| A | Ile | Thr | Asn | Ser | U |
| | Ile | Thr | Asn | Ser | C |
| | Ile | Thr | Lys | Arg | A |
| | Met | Thr | Lys | Arg | G |
| G | Val | Ala | Asp | Gly | U |
| | Val | Ala | Asp | Gly | C |
| | Val | Ala | Glu | Gly | A |
| | Val | Ala | Glu | Gly | G |

Chart for Coding of Amino Acids

L-3/T-1/CHE Date : 29/01/2017

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 451** (Fuels and Combustion Science)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) What is cogeneration system? Classify and describe different types of cogeneration systems with schematic diagram based on its prime mover. **(20)**

(b) A process industry has decided to install cogeneration plant. The process requirements are: **(15)**

– The plant requires 4.5 MW of electrical power

– The boiler has a maximum steam generating capacity of 31.25 TPH at 63 kg/cm$^2$ pressure and a temperature of 486 °C.

– The table below gives the process steam requirements

**Table 1. Process steam requirements**

| Process | Steam flow (TPH) | Pressure (kg/cm$^2$) | temperature (°C) | Enthalpy (kcal/kg) |
|---|---|---|---|---|
| Boiler | 31.25 | 63 | 486 | 808 |
| Process – 1 | 3.25 | 21 | 310 | 669 |
| Process – 2 | 8.00 | 8.0 | 174 | 662 |
| Process – 3 | 20.00 | 5.0 | 160 | 659 |

(i) Determine the total power that could be generated by a single turbine that meets the process steam requirements.

(ii) Calculate the additional amount of power to be purchased from the grid.

(iii) Calculate the heat to power ratio of the cogeneration plant.

The following data are given:

Alternator efficiency : 95%

Transmission efficiency : 95%

Thermal efficiency of turbine : 80%

1 KW electricity = 860 kcal/hr

2. (a) What are the basic types of boiler based on flow arrangement? Give their applicability for industry. Differentiate between sub-critical and supercritical boilers based on operating pressure, fluid phase behavior and efficiency rating spread. **(2+3+5)**

(b) 'Steam temperature varies with load' – Justify the statement with proper schematic of radiative and convective heating zones of a boiler showing the temperature profile. **(10)**

Contd ..... P/2

**CHE 451**

**Contd ... Q. No. 2**

(c) Develop an expression for the Carnot efficiency when the heat source and heat sink temperatures do not remain constant but change linearly as heat is being transferred. Draw the '$\sum \dot{Q}$' versus 'T' diagram for supercritical Rankine cycle and explain the nature of the diagram. **(10+5)**

3. (a) What is waste heat? Categorize waste heat in terms of temperature range. Draw the schematic of a hybrid recuperator and explain its function. **(1+3+6)**

(b) Why is the heat pipe considered as one of the efficient heat recovery unit? – explain with a neat sketch. **(10)**

(c) A reheating furnace has two burners that use furnace oil (FO). Combustion air is supplied directly at ambient temperature of 30°C. The company plans to install a recuperator to recover waste heat from the flue gases to preheat the combustion air to 300°C. Calculate the annual furnace oil savings using the following data: **(15)**

% $O_2$ in flue gas : 6%

Density of FO = 0.91 kg/Liter

Annual FO consumption : 740 tons

Specific heat of air at 300°C : 0.245 kcal/kg°C

Stoichiometric air to fuel ratio : 14 kg air/kg of FO

Furnace efficiency : 20%

GCV of FO : 10,200 kcal/kg

Cost of FO : USD 300/ton

4. (a) What is the basic difference between combustion and gasification of a solid fuel? Explain the following terms with respect to gasification process of solid fuels: **(4+3+3)**

(i) Steam reforming gasification

(ii) Hydro-gasification

(b) How can you produce different grade syn-gas (based on heating value) from gasification processes? What are the potential uses of these different grade syn-gases? **(7+7)**

(c) What are the slowest reactions involved in gasification process of solid fuels? – Explain their nature briefly. **(6)**

(d) What will be your preliminary consideration for UCG? – Describe briefly. **(5)**

Contd ..... P/3

## CHE 451

### SECTION – B

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

5. (a) A small island country depends mostly on imported crude oil for its energy needs. Some natural gas and coal are also imported and are used for power generation only. The details are given below for 2015: **(35)**

   crude oil produced : 112 ktoe; crude oil imported : 1085 ktoe

   coal imported : 619 ktoe; natural gas imported 6400 ktoe

   import of petroleum products : 3519 ktoe

   export of petroleum products : 140 ktoe

   The following are uses of petroleum products (ktoe) in the country:

   Road transport : 335; International transport : 254

   Industry : 519; Residential and commercial : to be calculated

   The following are the data regarding electricity generation and consumption:

| Electricity generation | Electricity consumption (ktoe) |
|---|---|
| Production 35 TWh | Residential and commercial 1193 |
| Losses and own-use 274 ktoe | Industry : to be calculated |

   Assume that the power generation efficiencies for coal, oil and natural gas based power plants are 25%, 32% and 36%, respectively. Also assume that the oil-refineries have their own consumption of 10 ktoe oil. Given : 1 TWh = 85.98 ktoe.

   Based on the given information, prepare the overall energy balance for the year 2015. [Use the provided table; attach it with the answer script]

6. (a) The attached figure shows the sector-wise gas consumption for Bangladesh for the year 2014-2015. Considering the current gas crisis do you recommend any changes in this usage pattern? Give appropriate reasons for your answer. **(15)**

   (b) The Barapukuria mine is built to operate with underground mining method. Do you think this is to extract coal from Barapukuria mine? Give your views on both underground and surface mining methods with respect to Barapukuria coal mine. **(20)**

7. (a) Briefly discuss the storage of liquid fuels (e.g. furnace oil). Why do we need to heat the fuel oil before pumping? **(6+2)**

   (b) "Proximate analysis indicates the percentage by weight of the fixed carbon, volatiles, ash and moisture content in coal" – Briefly discuss the information we can get from proximate analysis. Why do we need to perform ultimate analysis? **(10+2)**

   (c) With an appropriate sketch discuss the combustion of solid fuel on a grate. **(15)**

Contd ..... P/4

## CHE 451

8. (a) Discuss the perfect, the good and the incomplete combustion using the concept of three T's. **(9)**

(b) A coal has the following ultimate analysis (% by mass):

| | | | |
|---|---|---|---|
| Carbon | 90 | Nitrogen | 1 |
| Hydrogen | 3 | Sulphur | 0.5 |
| Oxygen | 2.5 | Ash | 3 |

Calculate:

(i) the volumetric air supply rate required if 500 kg/h of coal is to be burned at 20% excess air. Assume air density of 1.2 kg/m$^3$. **(10+5)**

(ii) The resulting %$CO_2$ (dry) by volume in the combustion products. **(6)**

(c) Define Lean and rich mixtures. **(5)**

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**Table for Question 5**

| **Supply and Consumption** | Coal | Crude oil | Oil Products | Natural Gas | Electricity | Total |
|---|---|---|---|---|---|---|
| Production | | | | | | |
| Imports | | | | | | |
| Exports | | | | | | |
| International Bunkers | | | | | | |
| TPES | | | | | | |
| Electricity | | | | | | |
| Oil Refineries | | | | | | |
| Other transformation* | | | | | | |
| TFC | | | | | | |
| Industry | | | | | | |
| Transport | | | | | | |
| Residential & Commercial | | | | | | |

* Includes transfers, statistical differences, energy industry own use, and losses

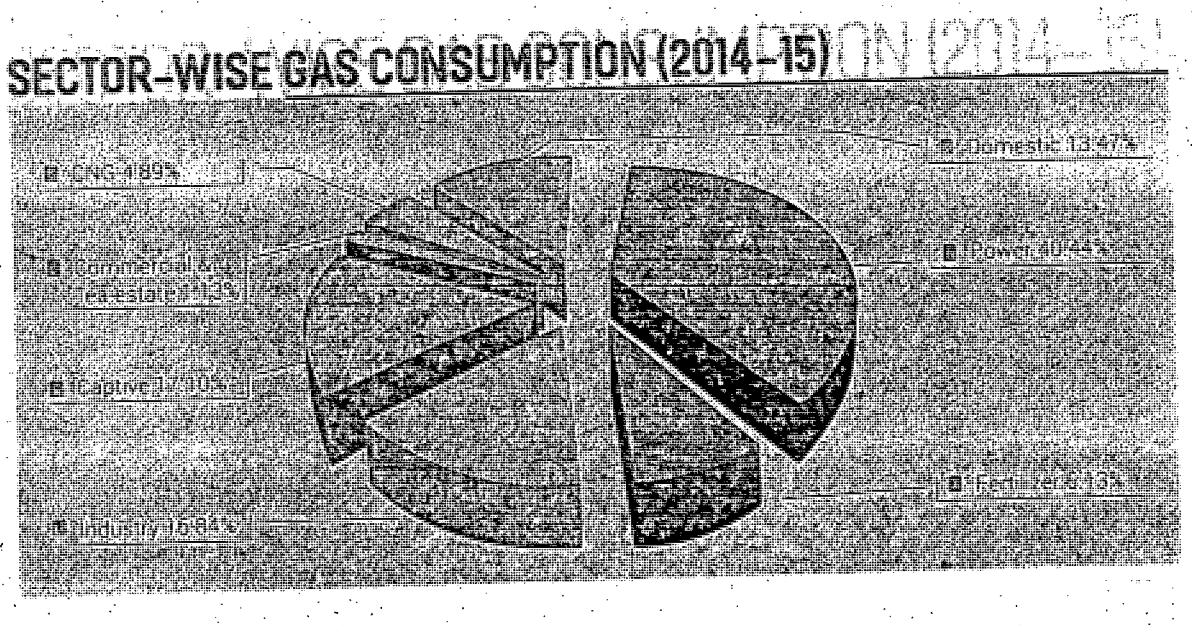


**Figure for Question 6(a)**

L-3/T-1/CHE Date : 04/02/2017

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 307** (Chemical Engineering Thermodynamics)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

A Data booklet is to be provided. Assume any missing data.

1. (a) With a neat sketch, describe a absorption refrigeration system. **(15)**

   (b) Fifty kmol/h of liquid toluene at 1.2 bar is cooled from 100°C to 20°C. A vapor compression refrigeration cycle is used for the purpose. Ammonia is the working fluid. Condensation in the cycle is affected by an air-cooled fin-fan heat exchanger for which the air temperature may be assumed essentially constant at 20°C. Determine the circulation rate of ammonia. **(20)**

   Data for ammonia:

$$\Delta H^{lv} = 23.34 \ {}^{kJ}\!/_{mol}$$

$$\ln P^{Sat} = 45.3 - \frac{4104.6}{T} - 5.14\,T + 615\,\frac{P^{Sat}}{T^2}$$

   where $P^{Sat}$ in bars and T in Kelvin.

2. (a) A refrigeration system requires 1.5 kW of power for a refrigeration rate of 4 kJ/s. **(5+5)**

   (i) What is COP and how much heat is rejected in the condenser.

   (ii) If heat rejection is at 40°C, what is the lowest temperature the system can possibly maintain?

   (b) Find the relation between standard Gibbs-Energy change and the equilibrium constant. **(15)**

   (c) Derive the relationship of $\prod_i (x_i)^{\nu_i} = K$. **(10)**

3. A bed of coal (assume pure carbon) in a coal gasifier is fed with steam and air, and produces a gas stream containing $H_2$, CO, $O_2$, $H_2O$, $CO_2$ and $N_2$. If the feed to the gasifier consists of 1 mol of steam and 2.38 mole of air, calculate the equilibrium composition of the gas stream at P = 20 bar for temperature of 1000 and 1500 K. **(35)**

Contd ..... P/2

## CHE 307

4. (a) Write a block diagram for the calculation of DEW T, by using Gamma-Phi formulation. Write necessary equations clearly. **(15)**

(b) For the cracking reaction,

$$C_3H_8\ (g) \rightarrow C_2H_4\ (g) + CH_4\ (g)$$

The equilibrium conversion is negligible at 300 K, but becomes close to equilibrium at temperature above 500 K. For a pressure of 1 bar, determine the

(i) fractional conversion of propane at 625 K. **(10)**

(ii) temperature at which fractional conversion is 85%. **(10)**

### SECTION – B

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

5. (a) Prepare a t-x-y diagram for a pressure of 90 kPa for Benzene (1)/Ethylbenzene (2) system. Assume the Raoult's law is valid. The parameter for Antoine equation **(15)**

| | A | B | C |
|---|---|---|---|
| Benzene | 13.86 | 2774 | 220 |
| Ethylbenzene | 14.00 | 3279 | 213 |

(b) A concentrated binary solution containing mostly species 2 (but $x_2 \neq 1$) is in equilibrium with a vapor phase containing both species 1 and 2. The pressure of this two phase system is 1 bar. The temperature is 25°C. Determine the good estimate of $x_1$ and $y_1$. $H_1 = 200$ bar and $P_2^{Sat} = 0.1$ bar. State and justify all assumptions. **(15)**

(c) Helium-laced gases are used as breathing media for deep-sea divers. Why? **(5)**

6. (a) A binary system of species 1 and 2 consists of vapor and liquid phases in equilibrium at temperature T, for which **(25)**

$$\ln \gamma_1 = 1.8\, x_2^2 \qquad \ln \gamma_2 = 1.8\, x_1^2$$

$$P_1^{Sat} = 1.24 \text{ bar} \qquad P_2^{Sat} = 0.89 \text{ bar}$$

Assuming the modified Raoult's law is valid.

(i) for what range of values of the overall mole fraction $z_1$ can this two phases system exist with a liquid mole fraction $x_1 = 0.65$?

(ii) What is the pressure P and vapor mole fraction $y_1$ within this range?

(iii) What are the pressure and composition of azeotrope at temperature T?

(b) Show that the partial properties are readily calculated directly from an expression for the solution property as a function of composition at constant T and P. **(10)**

Contd ..... P/3

## CHE 307

7. (a) Define fugacity. How would you estimate fugacity of a pure liquid? **(10)**

(b) The excess Gibbs energy of a binary liquid mixture at T and P is given by **(25)**

$$G^E/RT = (Ax_1 + Bx_2)\, x_1x_2$$

(i) Find expressions for $\ln\gamma_1$ and $\ln\gamma_2$ at T and P.

(ii) Show that these expressions satisfy the Gibbs-Duhem equation.

(iii) Show that $\left(\frac{d\ln\gamma_1}{dx_1}\right)_{x_1=1} = \left(\frac{d\ln\gamma_2}{dx_1}\right)_{x_1=0} = 0.$

8. The following is a set of VLE data for the system acetone (1)/methanol (2) at 55°C. **(35)**

| P/kPa | $x_1$ | $y_1$ | P/kPa | $x_1$ | $y_1$ |
|---|---|---|---|---|---|
| 68.73 | 0.000 | 0.000 | 98.46 | 0.543 | 0.617 |
| 75.28 | 0.057 | 0.129 | 99.95 | 0.633 | 0.677 |
| 78.95 | 0.104 | 0.219 | 100.46 | 0.733 | 0.738 |
| 86.76 | 0.217 | 0.363 | 101.06 | 0.792 | 0.787 |
| 93.20 | 0.358 | 0.478 | 99.80 | 0.945 | 0.934 |
| 96.36 | 0.448 | 0.551 | 96.88 | 1.00 | 1.00 |

(a) Find the parameter values for the two parameters Margules equation that provide the best fit of $G^E/RT$ to the data.

(b) Prepare a P-x-y diagram that compares the experimental points with the curves determined from the correlation.

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