2015-16
B.TECH. (WINTER VI/VIII SEMESTER) EXAMINATION
(CIVIL/ELECTRICAL/MECHENICAL/ELECTRONICS/COMPUTER/ARCHITECTURE/
CHEMICAL/PETRO-CHEMICAL ENGINEERING)
ATMOSPHERIC CHEMISTRY
(OPEN ELECTIVE) AC-308

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Marks allotted are indicated against each question.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) How is energy balanced in the atmosphere? Discuss it in detail. [05]
1(b) Define alternative fuel and describe various types of gasoline biofuels. [05]

OR

1'(a) Draw a labelled diagram of temperature vs altitude and mention the chemical [04]
species present in various regions.
1'(b) Write an explanatory note on indoor air quality. [06]

2(a) Give the classification of air pollutants. Discuss the sources and significance of [04]
hydrocarbons and oxides of nitrogen.
2(b) What are the physical and chemical characteristics of Particulate Matter? Distinguish between PM10 and PM2.5. [06]

3(a) Explain the determination of H₂S by methylene blue method. [04]

OR

Explain the PRA method for the estimation of SO₂. [06]
3(b) Discuss any four methods for the sampling of air pollutants. [06]

4(a) Discuss how substitution of raw material can be helpful in controlling the pollution. Give two examples. [03]
4(b) What is the principle of scrubbers? Discuss the working of Venturi scrubber. [03]
4(c) Explain the working of cyclone separator. [04]

Contd.....2.
5(a) Explain the different mechanisms involved in the nitrogen fixation.

OR

What is nitrification? What are the different enzymes involved in nitrification?

5(b) Explain the different steps involved in oxygen cycle.

6(a) Mention the impact of increased exposure to UV radiation on human health.

6(b) Discuss the catalytic destruction of ozone in the atmosphere.
1. Answer any three of the following:

(a) Perform one iterations of Bairstow method to extract a quadratic factor \(x^2 + px + q\) from the polynomial
\[x^3 + x^2 - x + 2 = 0.\]
Take \(p_0 = -0.9\) and \(q_0 = 0.9\).

(b) Use one iterations of Newton Raphson's method to determine a root of nonlinear equations
\[y \cos(xy) + 1 = 0; \sin(xy) + x - y = 0\]
Take \(x_0 = 1\) and \(y_0 = 2\).

(c) Transform the matrix \(A\),
\[
A = \begin{bmatrix}
1 & 2 & 2 \\
2 & 1 & 2 \\
2 & 2 & 1
\end{bmatrix}
\]
into tridiagonal form and hence find the eigenvector corresponding to the largest eigen value from the eigenvectors of the tridiagonal matrix.

(d) Obtain the Chebyshev linear polynomial approximation of second degree to the function \(f(x) = \sqrt{x}\) on the set of points \(\{0, 2/9, 4/9, 1\}\).

2. Answer any three of the following:

(a) Evaluate \(\int_{\pi/4}^{\pi/2} \frac{\cos x \ln(\sin x)}{\sin^2 x + 1} \, dx\) correct to 3-decimals, using Trapezoidal rule with the number of points 3, 5 & 9. Hence improve the result by using Romberg integration.

(b) Derive Gauss-Legendre three point formula and use it to evaluate the integral
\[I = \int_{2}^{3} \frac{\cos 2x}{1 + \sin x} \, dx\]
(c) Use Runge-Kutta method of order four to solve the system

\[ \frac{dy}{dx} = xz + 1 ; \quad \frac{dz}{dx} = -xy \]

with \( y(0) = 0 \) and \( z(0) = 1 \) at \( x = 0.3 \) with \( h = 0.3 \).

(d) Solve the boundary value problem \( y'' = y \) with \( y(0) = 0 \) and \( y(2) = 3.627 \) for \( h = 0.5 \) by finite difference method.

3(a) Solve the equation \( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0 \) at all internal points of the region given below:

![Grid diagram]

And hence use one iteration of Gauss-Seidel's method to improve the values of \( u \) at the internal mesh points.

(b) Solve the wave equation \( \frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial x^2} \)

with boundary conditions:

\( u(0, t) = 0 = u(1, t), \quad \frac{\partial u}{\partial t}(x, 0) = 0 \) and \( u(x, 0) = x - x^2 \), up to two time levels. Take \( h = 0.25 \) and \( k = 0.2 \) and write answers correct to two decimals.

4(a) Obtain a two parameter solution of the boundary value problem:

\[ y'' + y + 1 = 0, \quad y(0) = 0 = y(1) \]

by Galerkin method and collocation method for collocation points \( 1/3 \) and \( 2/3 \).

(b) Solve the boundary value problem:

\[ u'' - u = x, \quad u(0) = 0 = u(1) \]

by finite element method for \( h = \frac{1}{3} \).
2015-16
B.TECH. (WINTER SEMESTER) EXAMINATION

(Civil/Mechanical/ Electrical/Electronics/Computer/Chemical/Petrochemical/Architecture Engineering)

WATER RESOURCES AND WATERSHED MANAGEMENT
Open Elective

(CE-483)

Maximum Marks: 60 Credits: 04 Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1 (a) What is a watershed? Discuss in brief the following characteristics of a watershed. [08]
  (i) Slope (ii) Shape (iii) Elevation.
1(b) Define lag time and time of concentration. Estimate the lag time and time of concentration for the following data pertaining to a watershed:
    Hydraulic length= 900 m, contour interval = 1.5 m, land slope = 1.9 %
    The curve number for the soil and vegetative cover of the watershed = 80

    OR

    1'(a) Discuss the physical and chemical characteristics of water fit for drinking [05]
    1'(b) Enumerate different types of rain gauges. Discuss the float type rain gauge.
         Write the steps for finding the average depth of precipitation through Theissen polygon method.

2 Discuss the various steps involved in the planning of water-resources engineering projects. [15]

    OR

2' How does the economic viability of water resources project is determined? [15]
A 250 kW hydropower project has the following two alternatives for conveyance of water from the reservoir to the power house. Which of the alternatives is more economical? The annual interest rate may be taken as 6%.

**Ist Alternative:**
- Initial cost of the lined tunnel = Rs 2,00,000.00
- Useful life = 100 years
- Annual maintenance cost = Rs 15000.00

**IInd Alternative:**
- (i) Cost of power channel = Rs 500,000.00
- Useful life = 100 years
- Annual maintenance cost = Rs 10,000.00
- (ii) Cost of lining = Rs 150,000.00
- Useful life = 50 years
- Annual maintenance cost = Rs 7000.00
- (iii) Cost of penstocks = Rs 225,000.00
- Useful life = 50 years
- Annual maintenance cost = Rs 8000.00

3 Write brief notes on the following. [15]
   (i) Run off (ii) Soil Erosion (iii) Forms of precipitation

What is Rainwater harvesting? What are objectives of rainwater harvesting?

From a watershed the following information is available.

Area of watershed = 15 km². Calculate the flood discharge using Dicken’s formula.

The value of Dicken’s coefficient = 28.

4(a) Explain with neat diagram the hydrological cycle [05]

4(b) Discuss in brief structural and non-structural measures of flood control. [05]

4(c) Comment on groundwater balance and artificial groundwater recharge. [05]
2015-16
B.TECH. (WINTER SEMESTER) EXAMINATION
(MECH. / ARCH. / CIVIL. / CHEMICAL / PETROCHEMICAL / ELECTRICAL
/ ELECTRONICS / COMPUTER ENGINEERING)
(OPEN ELECTIVE)
SOLID WASTE MANAGEMENT
(CH-427)

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer the questions in the order stated in the question paper.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.

1(a) Discuss the factors which lead to the development of the stream of, ‘Solid Waste Management’. Explain the role played by of H.B. Parsons in developing this stream.

OR

1(a') What do you understand by Integrated Solid Waste Management? Explain.

1(b) Consider a household that generates a certain amount of waste per day. Of this amount, bottles and cans represents 20% by weight that are recycled by the family. 20% of the paper waste (32% total) is burned in the fire place. The remaining papers along with the rest of the waste is put into the container for collection. On a given day, 20 kg of consumer good (food, newspapers, magazines etc.) are brought into the house. The family consumes 7 kg of food that day and 5 kg of food is stored. The magazines represents 5% of the paper waste of that day, and they are not thrown away. Draw a material flow diagram of this problem and calculate the amount of solid wastes disposed of during this day.

2(a) Discuss the design of, ‘Manually Loaded Vehicles’ in the Stationary Container System.
2(a') Discuss the heuristic guidelines that should be taken into consideration in laying out the solid waste collection routes.

2(b) Design a solid waste curb collection system to service a residential area with 1000 families. Two manually loaded collection systems have to be evaluated. The first involves the use of a side loaded collection vehicle with one person crew and the other involves the use of rear loaded collection vehicle with two-person crew. Determine the size of the collection vehicle required and compare the labour requirements for each collection system. Assume the following data is applicable:

1. Average no of residents per family = 3.5
2. Solid Waste Generation Rate = 1.1 kg/capita.d
3. Density of solid waste = 120 kg/m³
4. Container per service = two 3m³ containers plus two 1m³ cardboard containers.
5. Collection frequency = once per week
6. Collection vehicle compaction ratio = 2.5
7. Round trip haul distance = 55 km
8. Nominal length of work day = 8 h
9. Trips per day = 2
10. Travel time to pickup location = 0.3 h
11. Travel time from last pickup location = 0.4 h
12. Off route factor = 0.15
13. Haul time constants, a = 0.016 h/trip, b = 0.03 km/h
14. At site time per trip = 0.10 h/trip

3(a) Discuss the various factors involved in the design of a landfill cover.
3(a') State and explain critical elements of leachate management system. [07]

3(b) Discuss and explain various phases involved in the generation of landfill gas. [08]

4(a) Explain the process of pyrolysis. Also discuss the effect of temperature on its product distribution. [07]

(OR)

4(a') What are biological conversion technologies involved in the transformation of solid waste? How do you select the process for a particular transformation? [07]

4(b) Determine the amount of oxygen required to oxidize 9000 kg of an organic solid waste aerobically. Assume that the initial composition of the organic material to be decomposed is given by $[C_6H_7O_2(OH)_3]_5$, that the final composition of the residual organic matter is estimated to be $[C_6H_7O_2(OH)_3]_3$, and that 400 kg of material remains after the oxidation process. [08]
Table - $A_1$

Representative data to use for computing equipment and labor requirements for various collection system$^a$

<table>
<thead>
<tr>
<th>Collection</th>
<th>Loading method</th>
<th>Compaction ratio, $r$</th>
<th>Time required to pick up loaded container and to deposit empty container, $h/\text{trip}$</th>
<th>Time required to empty contents of loaded container, $h/\text{container}$</th>
<th>At-site time, $h/\text{trip}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hauled container system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoist truck</td>
<td>Mechanical</td>
<td>-</td>
<td>0.067</td>
<td></td>
<td>0.053</td>
</tr>
<tr>
<td>Tilt- frame</td>
<td>Mechanical</td>
<td>-</td>
<td>0.40</td>
<td></td>
<td>0.127</td>
</tr>
<tr>
<td>Tilt- frame</td>
<td>Mechanical</td>
<td>2.0 - 4.0$^a$</td>
<td>0.40</td>
<td></td>
<td>0.133</td>
</tr>
<tr>
<td>Stationary container system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>compactor</td>
<td>Mechanical</td>
<td>2.0 - 2.5</td>
<td>0.008 - 0.05$^b$</td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>compactor</td>
<td>Manual</td>
<td>2.0 - 2.5</td>
<td>-</td>
<td></td>
<td>0.10</td>
</tr>
</tbody>
</table>

$^a$Containers used in conjunction with stationary compactor.

$^b$Time required varies depending on the size of the container.
Table - $A_2$

Labor requirements for manual curbside collection using a one-person crew

<table>
<thead>
<tr>
<th>Average number of containers and/or boxes per pickup location</th>
<th>Pickup time collector, min/ location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td>0.50 - 0.60</td>
</tr>
<tr>
<td>3 or more</td>
<td>0.92</td>
</tr>
<tr>
<td>Or unlimited service</td>
<td></td>
</tr>
</tbody>
</table>

Figure - A

Relationship between time requirements for pickup and percent of rear-of-house services for a two-person crew.
END SEMESTER EXAMINATION 2015-16
COMPUTER ENGINEERING
SELECTED TOPICS IN COMPUTER ENGINEERING – II (CO-447N)
B.TECH. (VI/VIII SEMESTER)
OPEN ELECTIVE

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question Marks
1(a) What are the responsibilities of Data Link Layer, Network Layer and Transport Layer? What are the differences among physical address, logical address and port address? [05]
1(b) What are the three major classes of Guided media? What is the significance of twisting in Twisted-pair cable? [05]
1(c) Explain the concept of CSMA/CD. If a network using CSMA/CD has 10Mbps bandwidth and maximum propagation time is 25.6 μs, what will be the minimum size of the frame? [05]

2(a) An ISP is granted a block of addresses starting with 190.100.0.0/16. The ISP needs to distribute these addresses to three groups of customers as follows:
  a. The first group has 64 customers; each needs 128 addresses
  b. The second group has 128 customers; each needs 256 addresses.
  c. The third group has 128 customers: each needs 64 addresses.
Design the sub-blocks and find out how many addresses are still available after these allocations. [05]

2(b) How does TCP provide reliability? Explain. [05]

2(c) Write short note on any TWO of the following: [05]
  1. A technique to improve Quality of Service
  2. Network Management
  3. Packet forwarding techniques

3(a) What are the advantages of a Database Management System over a File Processing System? [05]

OR

3'(a) What is database schema? Explain about the various keys with example. [05]

Contd.....2.
3(b) What is Relational Algebra? Briefly discuss any five operations of Relational Algebra.

OR

3'(b) Consider the following relations:

- department(dept_name, building, budget)
- course(course_id, title, dept_name, credits)
- instructor(ID, name, dept_name, salary)
- section(course_id, sec_id, semester, year, building, room_number, time_slot)

Write SQL for the following queries:
1. Find the names of all departments whose building name includes the substring ‘Watson’.
2. To find all courses taught in the 2009 Fall semester but not in the 2010 Spring semester.
3. List of those departments where the average salary of the instructors is more than $42,000

3(c) List the four types of database users. What is role of Database Administrator?

4(a) Explain the ACID properties of the transaction.

4(b) Compute the closure of the following set F of functional dependencies for relation schema r(A, B, C, D, E).

\[ A \rightarrow BC \]
\[ CD \rightarrow E \]
\[ B \rightarrow D \]
\[ E \rightarrow A \]

List the candidate keys for r.

4(c) Explain the purpose of the checkpoint mechanism. How often should checkpoints be performed?

OR

4'(a) What is a deadlock? How can one prevent the deadlock?

4'(b) During its execution, a transaction passes through several states, until it finally commits or aborts. List all possible sequences of states through which a transaction may pass. Explain why each state transition may occur.

4'(c) Discuss normalization forms 1NF, 2NF and 3NF.
2015-16
B.TECH. (WINTER VIII SEMESTER) EXAMINATION
(OPEN ELECTIVE)
(CIVIL / ARCHITECTURE / ELECTRICAL / ELECTRONICS / COMPUTER /
CHEMICAL / PETRO-CHEMICAL / MECHANICAL ENGINEERING)
PUMPS, BLOWERS AND COMPRESSORS
ME-437

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions. Assume suitable data if missing. Velocity Triangles are must where needed. Notations used have their usual meaning.

Q.No. Question

1(a) Define for a centrifugal pump:
Static head
Manometric head
Hydraulic efficiency
Volumetric efficiency
Mechanical efficiency.

1(b) A centrifugal pump has a suction lift of 1.5 m and delivery tank is 13.5 m. Delivery pipe velocity is 1.5 m/s. The radial velocity of flow is 3 m/s and the tangent to the vane at exit from the wheel makes an angle of 120° with the direction of motion. Find: (i) velocity of wheel at exit, (ii) velocity and pressure head at exit from the wheel (iii) desirable direction of fixed guide vanes

OR

1'(b) A Centrifugal Pump has an impeller of 18 cm outer dia, running at 1440 rpm discharges water at 10 m³/min against a head of 9 m, the inner dia is 9 cm, the vanes are set backward to outlet at 45°, area of flow is constant as 0.06 m². Find $\eta_{mech}$, vane angle at inlet and the least speed at which pump begins delivery.

2 Mention the advantages of air vessel in reciprocating pump. A single acting reciprocating pump draws water from a sump through a suction pipe 15 cm in dia and 12 m long, the suction lift is 3 m. The cylinder dia is 22 cm, stroke is 46 cm, crank rotates at 20 rpm, air vessel is fitted at the cylinder level and at a distance 1 m from it, neglect friction in 1 m portion, determine the pressure in the cylinder at the beginning and middle of suction stroke.
3 For an axial fan stage with upstream guide vanes (UGV) (R > 1) derive the expression for (i) stage work, $W_{st}$ (ii) stage pressure coefficient, $\psi$ (iii) pressure rise in the rotor, $(\Delta p)_r$, (iv) Degree of reaction, $R$.

OR

3' An axial fan stage consisting of only a rotor has the following data:
(i) rotor blade air angle at exit 10° (ii) tip diameter 60 cm (iii) hub diameter 30 cm
(iv) rotational speed 960 rpm (v) power required 1 kW, (vi) flow coefficient 0.245
(inlet flow conditions $p_i = 1.02$ bar, $T_i = 316$ K)
Determine the rotor blade angle at the entry, the flow rate, stage pressure rise, overall efficiency, degree of reaction and specific speed.

4 An axial compressor stage has the following data:
(i) Temperature and pressure at entry 20 °C, 1.0 bar
(ii) Degree of reaction 50%
(iii) Mean blade ring diameter 36 cm
(iv) Rotational speed 18000 rpm
(v) Blade height at entry 6 cm
(vi) Air angles at rotor and stator exit 25°
(vii) Axial velocity 180 m/s
(viii) Work-done factor 0.88
(ix) Stage efficiency 85%
(x) Mechanical efficiency 96.7%

Determine: (a) Air angles at the rotor and stator entry, (b) the mass-flow rate of air, (c) the power required to drive the compressor, (d) the loading coefficient, (e) the pressure ratio developed by the stage and (f) the Mach number at the rotor entry.

OR

4' The conditions of air at the entry of an axial compressor stage are $p_i = 768$ mm of Hg and $T_i = 314$ K. The air angles are $\beta_1 = 51^\circ$, $\beta_2 = 9^\circ$, $\alpha_1 = \alpha_3 = 7^\circ$. The mean dia and peripheral speed are 50 cm and 100 m/s. Mass flow rate through the stage is 25 kg/s, the work done factor is 0.95 and mechanical efficiency is 92%, take stage efficiency 88%, determine: (i) air angle at the stator entry (ii) blade height at the hub-tip dia ratio (iii) stage loading coefficient (iv) stage pressure ratio (v) power to drive the stage.

5(a) Define unit and specific quantities. Derive the expression for specific speed of a pump.

5(b) A quarter scale model of a turbine is tested under a head of 36 m. The full scale turbine
2015-16
B.TECH. (WINTER SEMESTER) EXAMINATION
ALL BRANCHES
(HEATING, VENTILATION AND AIR CONDITIONING)
(OPEN ELECTIVE)
ME 461

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Use of tables and charts is allowed.

Q.No. Question
1(a) Write a short note on physiological considerations for human comfort? Also explain and sketch the comfort chart?

1(b) What do you mean by air conditioning. Explain central and unitary air conditioning systems with neat and clean diagrams.

OR

1' A retail shop located in a city at 30°N latitude has the following loads:
Room sensible heat = 58.15 KW
Room latent heat = 14.54 KW
The summer outside and inside design conditions are:
Outside: 40°C DBT, 27°C WBT
Inside: 25°C DBT, 50% RH
70m³/min of ventilation air is used.
By pass factor = 0.15
Dry bulb temperature of mixed air entering the cooling coil = 29.2°C
Dry bulb temperature of air leaving the cooling coil = 13.7°C
Determine:
   a) Ventilation load
   b) Grand total heat
   c) Apparatus dew point of coil
   d) Effective room sensible heat factor

It is required to design an air conditioning system for a restaurant with the following data:

Inside design conditions........................................... 24°C DBT, 55% RH
Outdoor conditions..................................................... 39°C DBT, 28°C WBT
Infiltrated air............................................................. 16 m³/min
No of occupants.......................................................... 30
Sensible heat gain per person......................................... 60 W
Latent heat gain per person............................................ 60 W
Internal lighting load................................................... 20 lamps of 100 W
Internal lighting load................................................... 12 fluorescent tubes of 60 W
Solar heat gain through walls, roof and floor................. 6.1 KW
Solar heat gain through glass...................................... 5.6 KW
Sensible heat gain from other sources........................... 12.2 KW
By-pass factor of coil.................................................. 0.2
Dry bulb temperature of mixed air entering the cooling coil.. 27.6°C
Dry bulb temperature of air leaving the cooling coil........ 14.4°C

Determine:
   a) Dew point temperature of coil
   b) Condition of supply air to the room
   c) Capacity of the conditioning plant
   e) Grand sensible heat factor
3(a) What are different pressure losses in ducts? Also explain Equal friction method of duct sizing?

3(b) Sketch and explain flow patterns in the room with:
   a) supply system
   b) extraction system
   c) combined supply and extraction system, of ventilation?

4(a) What are radiators and convector in a hot water or steam heating system? Sketch neatly one pipe and two pipe water heating system?

4(b) Sketch the arrangements for the four types of hydronic piping system arrangements?

4(c) Sketch a functional block control diagram for an open loop and for a closed loop system. Label and describe basic elements?

5(a) Giving neat sketches briefly explain a bi-metallic element used as thermostat?

5(b) Explain the working principle of pneumatic control system with neat and clean diagram.

   OR

5'(a) Sketch a block diagram of basic elements of a control unit?

5'(b) Explain the working principle of electric and electronic control systems with neat and clean diagrams.
2015-16
B.TECH. (WINTER SEMESTER) EXAMINATION
(Open Elective)
Process Design & Integration
PK 443P

Maximum Marks: 60 \hspace{1cm} Credits: 04 \hspace{1cm} Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. \hspace{1cm} Question \hspace{1cm} M.M.
1(a) \hspace{1cm} List down various decisions to be made at Input –Output level of process synthesis. \hspace{1cm} [04]
1(b) \hspace{1cm} What are the advantages and limitations of batch processes? Mention the situations that favour batch production. \hspace{1cm} [04]
1(c) \hspace{1cm} Which of the following alternatives (A or B) is superior over a 30 years period if the interest rate is 7% per year?

<table>
<thead>
<tr>
<th>alternative A</th>
<th>alternative B</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>brick</td>
</tr>
<tr>
<td>life</td>
<td>30 years</td>
</tr>
<tr>
<td>initial cost</td>
<td>$1800</td>
</tr>
<tr>
<td>maintenance</td>
<td>$5/year</td>
</tr>
</tbody>
</table>

OR.

1 (c') \hspace{1cm} You borrow $35,000 from a bank at 10.5% annual interest to purchase a multi-cone cyclone rated at 50,000 ft³/min. If you make monthly payments of $325 (at the end of the month), how many payments would be required to pay off the loan? \hspace{1cm} [07]

2(a) \hspace{1cm} Outline in brief, the classification of reactors. \hspace{1cm} [02]

2(b) \hspace{1cm} A 10-minute experimental run shows that 75% of liquid reactant is converted to product by a half-order reaction. What would be the fraction converted in a half-hour run? \hspace{1cm} [05]

2(c) \hspace{1cm} Under appropriate conditions, A decomposes in a plug flow reactor as follows:

\[
A \xrightarrow{k_1=0.1/min} R \xrightarrow{k_2=0.1/min} S
\]

Contd.... 2.
R is to be produced from 1000 t/h of feed in which \( C_{A0} = 1 \text{ mol/l} \) and \( C_{R0} = C_{S0} = 0 \).

What is the maximum concentration of R (\( C_{R,\text{max}} \)) in the effluent stream of the reactor?

3(a) List down the various liquid-liquid separation processes.

3(b) Write down the various heuristics for distillation sequencing. A mixture of Alkane (Table 1) is to be separation by a train of simple distillation column. Outline all the possible separation sequence. Also, comment on heuristics for optimum sequence of the mixture, given in Table 1.

### Table 1: Data for mixture of alkane

<table>
<thead>
<tr>
<th>Components</th>
<th>Flow rate (kmol/h)</th>
<th>Boiling point (K)</th>
<th>Relative volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Propane</td>
<td>45.4</td>
<td>231</td>
<td>5.78</td>
</tr>
<tr>
<td>B. i-Butane</td>
<td>136.1</td>
<td>261</td>
<td>2.98</td>
</tr>
<tr>
<td>C. n-Butane</td>
<td>226.8</td>
<td>273</td>
<td>2.36</td>
</tr>
<tr>
<td>D. i-Pentane</td>
<td>181.4</td>
<td>301</td>
<td>1.00</td>
</tr>
</tbody>
</table>

OR

3 (b') Describe the working of a centrifugal separator. Derive the expression for the size of the smallest liquid-droplet that can be removed from a gas mixture by a centrifuge.

4(a) Write a short note on pinch technology.

4(b) Find the minimum heating load, the minimum cooling load and the process to process heat transfer for a heat exchanger network data (given in Table 2) using problem table algorithm (PTA). Design a heat exchanger network for the maximum energy recovery above and bellow the pinch.

OR

4(b') Calculate the total network heat transfer area of the system given in Table 2, for \( \Delta T_{\text{min}} = 10 \, ^\circ \text{C} \), if condensing steam at 240 \( ^\circ \text{C} \) (heat transfer coefficient = 1400 W/m\(^2\).\(^\circ\text{C}\)) is used for hot utility and cooling water (entering at 15 \( ^\circ \text{C} \), returning at 25 \( ^\circ \text{C} \) and heat transfer coefficient = 600 W/m\(^2\).\(^\circ\text{C}\)) as cold utility.

### Table 2

<table>
<thead>
<tr>
<th>Stream No.</th>
<th>Supply Temp ((^\circ\text{C}))</th>
<th>Target Temp. ((^\circ\text{C}))</th>
<th>Heat Capacity Flow rate (kW/(^\circ\text{C}))</th>
<th>Heat Transfer Coefficient (W/m(^2).(^\circ\text{C}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>180</td>
<td>.60</td>
<td>3.0</td>
<td>560</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>30</td>
<td>1.0</td>
<td>400</td>
</tr>
<tr>
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<td>20</td>
<td>135</td>
<td>2.0</td>
<td>350</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>140</td>
<td>4.5</td>
<td>440</td>
</tr>
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