2014-15
B.TECH. AUTUMN (VIII SEMESTER) EXAMINATION
(CHEMICAL ENGINEERING)
ENERGY RESOURCES AND UTILIZATION
(CH-413, Backlog)

Maximum Marks: 60  Credits: 04  Duration: Three Hours

Answer all the questions.

Q.No.  Question  M.M.
1(a)  Explain in detail the experimental method for the determination of calorific value of a solid fuel. [05]
1(b)  Give the classification of coal by Rank. [02]
1(c)  List out the various future energy resources in India. And also give their total energy consumption in India. [05]

OR

1(c)' Discuss the Proximate Analysis of a solid fuel and its importance? [05]

2(a)  What is Blast furnace gas? Give its composition and uses. [03]
2(b)  Describe various type of burners used in chemical and allied industries. [05]
2(c)  Discuss the potential of hydrogen as a source of Energy. Discuss its future prospects. [04]

OR

2'(a)  Explain the various steps involved in coal preparation in power generation. [05]
2'(b)  Calculate the gross and net calorific value of a coal which gave following analyses:
       C=74%, H=6%, N=1%, O=9%, S=0.8%, Moisture=2.2%, Ash=8%.
       [04]
2'(c)  Explain the classification of fuels with its advantages and disadvantages. [03]
3(a) Describe the production of ethanol from cellulosic biomass with the help of a process flow diagram?

OR

3(a)' Explain the mechanism of Biogas formation along with the effect of temperature and pH at the rate of bio gas formation.

3(b) Differentiate between Floating head and Fixed dome type of digester.

4(a) Classify the methods for the utilization of Solar Energy.

4(b) Calculate the angle made by beam radiation with the normal to a flat plate collector on May 1 at 0900 hr (Local apparent time). The collector is located in New Delhi (28°35'N, 77°12'E). It is tilted at an angle of 36° with the horizontal and is pointing due south.

OR

4(b)' Describe the performance analysis of liquid flat plate collector.

4(c) Describe the working of Solar Pond.

5(a) List the devices for the efficient recovery of energy from solid, liquid and gases fuel. Explain one of them.

5(h) How will you conserve energy in Nitrogenous fertilizers industry or steel industry?

5(c) What do you understand by Energy Audit? Explain its need in present scenario.
B. TECH. (WINTER SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
MODELING, SIMULATION AND OPTIMIZATION
CH 420

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Neat diagrams must be drawn wherever necessary.

1(a) State the law of mass action. Explain the process modeling methodology and explain in brief how process models are used.

1(b) Give different uses of mathematical model. What are limitations of mathematical models?

OR

1′(a) Draw a flowchart showing the major steps in process modeling. Show the interrelations between the flowchart stages. List in brief, along each major step, the key issues for each major modeling task.

1′(b) Formulate process model for cooling of fluid in circular pipe under plug flow condition of velocity. List the assumption.

2(a) Develop model for a counter current heat exchanger that also involves separating a mixture of gas by permeating through a semi permeable material. The apparatus consists of a thin walled glass tube enclosed in larger tube. Through which the flows of mixture of gases A and B at high pressure. Gas permeates from the shell side and flow through wall of the tube. Develop the algorithm for the above scenario.

2(b) Develop a model for Shell & Tube Heat exchanger listing the assumptions. Suggest a suitable algorithm to solve the model.

OR

2(b′) Develop the mathematical model of a multiple effect evaporator. Draw a neat figure of the same.

3(a) Consider the following 3 reactions taking place in continuously stirred tank reactor (CSTR) in the liquid phase.

\[ \text{A} \xrightarrow{r_1} \text{2B}, \text{ Where } r_1 = K_1 C_A \]

\[ \text{A} \xrightarrow{r_2} \text{C}, \text{ Where } r_2 = K_2 C_A^{1.5} \text{ and } r_3 = K_3 C_C^2 \]

\[ \text{A} \rightarrow \text{D} \]

\[ r_4 = K_4 C_A \]

\[ r_5 = K_5 C_C \]

\[ r_6 = K_6 C_D \]

\[ r_7 = K_7 C_B \]

\[ r_8 = K_8 C_C \]

\[ a_0 \text{ with } a = 2 \]
Derive the equations that can be solved for the steady state concentrations of A, B, C and D. You may assume that species A is fed to the reactor in a single stream, flowing at Q (m³/s), with a concentration of C in A. State all other assumptions that you make while answering the question. Note: Do not simplify your equations.

OR

3(a) Compare relative merits and demerits of fluidized and packed bed reactors.

3(b) Consider the modeling of a jacketed CSTR, fed with a single inlet stream. Under some fairly straightforward assumptions, show that the steady temperature of the fluid leaving the tank is given by:

\[
\frac{F_{\text{in}}}{V} [T_{\text{in}} - T] - \frac{U A S}{\rho c_p} [T - T_f] + \frac{2 k_f (-\Delta H_f)}{\rho c_p} C_2^0 \exp\left(\frac{-E_p}{RT}\right) = 0
\]

4(a) Why optimization of chemical process is necessary? Explain essential features of optimization.

4(b) An oil refinery produces two products: jet fuel and gasoline. The profit for the refinery is $0.10 per barrel for jet fuel and $0.20 per barrel for gasoline. The following conditions must be met.

i. Only 10,000 barrels of crude oil are available for processing.

ii. The refinery has a government contract to produce at least 1,000 barrels of jet fuel.

iii. The refinery has a private contract to produce at least 2,000 barrels of gasoline.

iv. Both products are shipped in trucks; the delivery capacity of the truck fleet is 180,000 barrel-miles.

v. The jet fuel is delivered to an airfield 10 miles from the refinery.

vi. The gasoline is transported 30 miles to the distributor.

How much of each product should be produced for maximum profit?
Questions

Q.No. | M.M.
---|---
1(a) | [10]
Briefly describe the uses of steam in a process plant and discuss the basic steam cycle with the help of a neat diagram.

1(b) | [05]
What does the term utility signify? Differentiate between the primary and secondary utilities along with their relevant examples.

OR

1(b') | [05]
What are the roles of super heaters and economizers? Explain.

2 | [15]
A company has the option of investing in one of the two projects A or B. The capital cost of both projects is Rs. 1 Crore. The predicted annual cash flows for both projects are shown in Table 1. For each project draw cumulative cash flow diagram and calculate the:

(i) Payback time
(ii) Return on investment (ROI)
(iii) Discounted cash flow rate of return (DCFRR)

What do you conclude from the result?

Table 1: Cash flows for two competing projects

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash flows Rs.10^6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project A</td>
</tr>
<tr>
<td>0</td>
<td>-10.0</td>
</tr>
<tr>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>5.2</td>
</tr>
<tr>
<td>5</td>
<td>6.4</td>
</tr>
</tbody>
</table>

contd...
OR

3'(a) The purchased cost of a new absorption column installation is Rs. 500 lakhs. Calculate the annual cost of installed capital if the capital is to be annualized over a period of five years at a fixed rate of interest of 5%. Also derive the equation used.

3'(b) A new heat exchanger is to be installed as part of a large project. Preliminary sizing of the heat exchanger has estimated its heat transfer area to be 500 m². Its material of construction is low-grade stainless steel, and its pressure rating is 5 bar. Using the data given in Table 2 estimate the contribution of the heat exchanger to the total cost of the project (CE Index of Equipment = 441.9).

### Table 2: Typical factors for capital cost based on delivered equipment costs

<table>
<thead>
<tr>
<th>Equipment</th>
<th>CE Index</th>
<th>Material of construction</th>
<th>Capacity measure</th>
<th>Base size $Q_a$</th>
<th>Base cost $C_3$ (Rs.)</th>
<th>Size range</th>
<th>Cost exponent $M$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell and tube heat exchanger</td>
<td>435.8</td>
<td>CS</td>
<td>Heat transfer area (m²)</td>
<td>80</td>
<td>$1.64 \times 10^4$</td>
<td>80–4000</td>
<td>0.68</td>
</tr>
</tbody>
</table>

\[
f_M = 2.9, f_{BR} = 0.4, f_{NP} = 0.7, f_{HP} = 0.2, f_{HAC} = 0.1, f_{HIL} = 0.5, f_{OS} = 0.2, f_{HAD} = 0.2,
\]
\[
f_{BR} = 0.1, f_{DEC} = 1.0, f_{CON} = 0.4, f_{wCE} = 0.7
\]

4(a) What are the different types of process hazards? Write a short note on any two of them.

4(b) Describe and differentiate between the following terms:

(i) Deflagration and detonation
(ii) Confined and unconfined explosion
(iii) LD₅₀ and threshold limit value

4(a) With the help of a neat diagram explain the difference between fault tree and event tree. Depict the sequence of events leading to the failure of a typical flow system (consisting of a pump having both in-let and out-let pipe lines fitted with valves) with the help of a fault tree.

OR

4(a') What do you understand by the terms 'fire triangle' and 'fire tetrahedron'? Differentiate between them and with the help of a neat diagram develop and explain the fault tree for both of them.
4(b) Figure 1 shows a heat exchanger present in some section of a process plant before the HAZOP analysis with control valves installed in both the up-streams. Carry out the preliminary HAZOP analysis over all the possible nodes and mention the additional instrumentation and safety measures required after the preliminary HAZOP analysis.

![Fig. 1: Heat Exchanger in a Process Plant](image-url)

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2014-15
B.TECH. (WINTER SEMESTER) EXAMINATION
(Chemical Engineering)
SELECTED TOPICS IN CHEMICAL ENGINEERING
CH-422N

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.: 60
1(a) Explain the following with respect to membranes:

(i) Permeance 
(ii) Selectivity 
(iii) Cut fraction 
(iv) Permeability 
(vi) Retentate. 

1(b) What are the main features of membrane processes. (4)
1(c) Explain the idealized flow patterns in membrane modules. (5)

OR

1'(a) What are the qualities that a membrane should have to be effective for separation. (3)
1'(b) Differentiate between plate and frame, and hollow fiber modules. (4)
1'(c) Describe the mechanisms of separation in porous membranes. (8)

2(a) With the help of diagrams explain the two industrial applications of pervaporation. (4)
2(b) Explain the process of dialysis giving its industrial examples. Also write the equipments used for it. (6)
2(c) Calculate the flux and the rate of removal of urea at steady state in g/h from

...2
blood in cellophane membrane dialyzer at 37°C. The membrane is 0.025 mm thick and has an area of 2.0 m². The mass transfer coefficient on blood side is estimated as 1.25*10⁻⁵ m/s and that on the aqueous side is 3.33*10⁻⁵ m/s. The permeance of membrane is 8.73*10⁻⁸ m/s. The concentration of urea in the blood is 0.02g urea per 100 ml and that in the dialyzing fluid is zero.

3(a) Write short notes on:
   (i) Wind rose
   (ii) Global programs of air pollution control

3(b) Explain the following:
   (i) Environmental lapse rate
   (ii) Dry adiabatic lapse rate
   (iii) Sub adiabatic lapse rate
   (iv) Super adiabatic lapse rate

3(c) With the help of a neat diagram explain the working of any equipment for particulate control.

4(a) Explain the source and environmental significance of the following contaminants:
   (i) Suspended solids
   (ii) Color
   (iii) Biodegradable organics
   (iv) Odour

4(b) An activated sludge system is to be used for secondary treatment of 10,000 m³/d of industrial wastewater. After primary clarification the COD is 150 mg/l and is desired to have not more than 5mg/l of soluble BOD in effluent. A completely mixed reactor is to be used and pilot plant analysis has established the kinetic values as Y = 0.5 kg/kg, kₐ = 0.05d⁻¹. Assuming an MLSS concentration of 3000 mg/l from the secondary clarifier determine (i) the volume of the reactor, (ii) the mass and volume of solids that must be wasted each day and (iii) recycle ratio.
Q.No.  

1. (a) Explain various types of errors encountered during measurement process. What are the typical sources for these types of error? In what ways can the act of measurement cause a disturbance in the system being measured? What steps can be taken to minimize the effect of environmental inputs in measurement systems?  

(b) Discuss various modes of transmission of instrument reading.  

2. (a) Explain the working of gas chromatograph, capillary flow viscometer and McLeod gauge.  

(b) Give a step-by-step application guide from raw materials to final product for measuring technology used in the cement industry.  

3. Write detailed notes on any five different types of instruments used for Flow Measurement mentioning their working principle, operating range, application etc. Draw neat and well labelled diagrams.  

OR  

3'. Write detailed notes on any five different types of instruments used for Temperature Measurement mentioning their working principle, operating range, application etc. Draw neat and well labelled diagrams.  

4. With the help of a neat diagram explain the working of Capacitive Hygrometer, Psychrometer, Dew Point Meter, Induction Hydrometer, and Thermohydrometer.
1(a) Briefly describe four major causes of pollution due to chemical process industries. [02]

1(b) Differentiate between Water (Prevention and Control of Pollution) Act, 1974 and Water (Prevention and Control of Pollution) Cess Act, 1977. [03]

1(c) Discuss various parameters for characterization of a wastewater sample and their significance with respect to green technology. [10]

OR

1(e) Discuss various parameters for characterization of a Municipal Solid Waste sample. What are their limits of acceptance? [10]

2(a) List four process characteristics of an air pollution control device. [02]

2(b) Describe four flue gas desulfurization process along with their chemical reactions. [08]

2(c) Find the diameter of the particles that will be removed from a settling chamber, given that velocity of the particle \( V = 0.33 \text{ m/s} \), viscosity of air \( \mu = 2 \times 10^{-5} \text{ kg/m.s} \), specific gravity of particle \( SG = 2.0 \), settling chamber length \( L = 8 \text{ m} \), height of the chamber \( H = 2 \text{ m} \) and density of particle \( \rho_p = 2000 \text{ kg/m}^3 \). [05]

OR

2(c) An Electrostatic Precipitator with 6000 m² of collector area is 97% efficient in treating 200 m³/sec of flue gas from a 200 MW power plant. How large would the collector area need to be? [05]

2(c) contd... 2
plate have to be, to increase the efficiency from 97% to 98% and to 99% respectively.

3(a) Differentiate between facultative lagoon and extended aeration lagoon.

3(b) Discuss the reaction mechanism of any four chemical coagulants used in water treatment.

3(c) Raw wastewater with BOD of 250 mg/l is applied to a wastewater treatment plant based on ASP. If the primary treatment units remove 30% of the BOD, determine the MLVSS to be maintained in the reactor to control an F/M ratio of 0.5, assuming a wastewater flow rate of 0.8 MLD

OR

3(c)' For an Activated Sludge Process (ASP) system, estimate the Mean Cell Residence Time (MCRT) and Recirculation Ratio (R) for the given data:
   i) Daily average inflow of wastewater \( Q_{in} = Q_a = 20 \text{ MLD} \)
   ii) Effluent flow rate of wastewater \( Q_e = 10 \text{ MLD} \)
   iii) Sludge wasting rate \( Q_w = 0.1 \text{ MLD} \)
   iv) Hydraulic Retention Time (HRT) = 5 hours
   v) Active biomass concentration in reactor \( X = 5,000 \text{ mg/l} \) (MLVSS)
   vi) Biomass concentration in effluent \( X_e = 50 \text{ mg/l} \)
   vii) Biomass concentration in return line \( X_r = 10,000 \text{ mg/l} \)

4(a) Discuss the criteria for identifying a hazardous waste.

4(b) Draw a flow diagram for identifying hazardous waste management options.

4(c) With the help of a flow diagram describe the utilization of solid waste generated from a Pulp and Paper industry for making low grade paper board.

OR

4(c)' With the help of a flow diagram describe the utilization of solid waste generated from a Vegetable oil refining industry for making soap.