2013-14  
B.TECH. (WINTER SEMESTER) EXAMINATION  
CHEMICAL ENGINEERING  
PROCESS PLANT DESIGN  
CII-421N  

Maximum Marks: 60  
Credits: 05  
Duration: Three Hours  

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

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>What are the various stages through which a plant design project moves towards completion? Briefly describe each of them.</td>
<td>08</td>
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<tr>
<td>1(b)</td>
<td>What are the various important factors that should be considered for selecting a proper plant site?</td>
<td>04</td>
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<td></td>
<td><strong>OR</strong></td>
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<tr>
<td>1'(a)</td>
<td>Why is it necessary to carry out the feasibility survey before starting any plant design project and what are its main contents?</td>
<td>08</td>
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<tr>
<td>1'(b)</td>
<td>Write down the standard procedure followed while commissioning a typical process plant and describe each step briefly.</td>
<td>04</td>
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<tr>
<td>2(a)</td>
<td>Briefly describe the uses of steam in a process plant and discuss the basic steam cycle with the help of a neat diagram.</td>
<td>08</td>
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<td>2(b)</td>
<td>What does the term utility signify? Differentiate between the primary and secondary utilities along with their relevant examples.</td>
<td>04</td>
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<td></td>
<td><strong>OR</strong></td>
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<tr>
<td>2(b')</td>
<td>Differentiate the roles of superheaters and economizers.</td>
<td>04</td>
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</table>
| 3 | 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) | [12] |
(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>Project A</th>
<th>Project B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.0</td>
<td>-10.0</td>
</tr>
<tr>
<td>1</td>
<td>1.6</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>2.8</td>
<td>5.2</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>5.2</td>
<td>2.8</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>1.6</td>
</tr>
</tbody>
</table>

OR

3'(a) What do you understand by the term "Battery Limit Investment" and how is it estimated?

3'(b) A new heat exchanger is to be installed as part of a larger 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 Qs</th>
<th>Base cost C0 (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 x 10⁶</td>
<td>80-4000</td>
<td>0.58</td>
</tr>
</tbody>
</table>

4(a) What are the various layers of plant safety? Explain the role of each layer in ensuring the safe operation of a plant.

4(b) Describe the significance of the following:

(i) Failure Mode Effect Analysis (FMEA)

(ii) Materials Safety Data Sheets (MSDS)

5(a) Differentiate between the fault tree and event tree. Depict the sequence of events leading to the rupture of a typical pressure vessel with the help of a fault tree.

OR
5(a') What do you understand by the term fire triangle? With the help of a neat diagram develop and explain the fault tree for a typical fire triangle.

5(b') Figure 1 shows the basic instrumentation and control systems required for the steady state operation of the reactor section of nitric acid plant before the HAZOP analysis. Carry out the preliminary HAZOP analysis over the ammonia vaporiser and the reactor, and mention the additional instrumentation and safety trips required after the preliminary HAZOP analysis.

![Diagram of reactor section of a nitric acid plant]

**Fig. 1: Reactor section of a nitric acid plant**
1. Differentiate between the following with the help of diagrams:
   
   a) Co-current and cross current flow patterns in membrane module.
   
   b) Hollow fiber and tubular modules.
   
   c) Capillary condensation and Knudsen diffusion mechanisms of separation for porous membranes.

OR

1(a) Discuss about the materials used for various types of membranes.

1(b) With the help of a neat sketch explain the working of a plate and frame membrane module.

1(c) Derive the equation of steady state flux \( N_A \) for series resistances in membrane.

2(a) Explain the process of gas permeation with its industrial applications.

2(b) Derive the relation for solute rejection \( R \) on the basis of diffusion model for reverse osmosis.

2(c) Calculate the flux and the rate of removal of urea at steady state in g/h from 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 \( 1.25 \times 10^{-5} \) m/s and that on the aqueous side is \( 3.33 \times 10^{-2} \) m/s. The permeance of membrane is \( 8.73 \times 10^{-6} \) 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) Define dust, mist, and smoke.

3(b) An industrial emission has the following characteristics: \( N_2 \) = 50%, \( O_2 \) = 15%.
CO$_2$—33%. You are called in as a consultant to advise on the type of air pollution control equipment. What would be your recommendation?

3(c) The temperature of an air parcel at 500 m is 25°C. If this is moved upward to 1000 m, what would be its temperature if the conditions are

(i) Subadiabatic
(ii) Superadiabatic

3(d) A dust has particles with a drift velocity of about 0.15 m/s. For a total air flow of 60 m$^3$/s, what must be the number of 10 m $\times$ 10 m collecting plates of an ESP in order to achieve 90% removal?

OR

3'(a) What are the sources of particulates? Also discuss their effect on human health, plants, animals and materials.

3'(b) Explain the working of a gravitational settling chamber. A settling chamber that is 12 m long, 2 m high and 2 m wide, processes 240 m$^3$/m of air at a temperature of 77°C. Determine the maximum size of the particle with specific gravity of 1.8 that is removed with a theoretical efficiency of 100 percent. (given: the viscosity of air at 77°C is 2.1 $\times$ 10$^{-5}$ kg/m-s)

3'(c) Explain with the help of a neat sketch, the working of any wet collector for particulate removal.

4(a) An activated sludge system is to be used for secondary treatment of 10,000 m$^3$/d of industrial wastewater. After primary clarification the BOD is 150 mg/l and is desired to have not more than 5 mg/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, k$_d$ = 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.

4(b) Explain the source and environmental significance of the following contaminants:

(i) Suspended solids
(ii) Temperature
(iii) Color
(iv) Biodegradable organics
(v) Turbidity
2013-14
B.TECH. (VIII SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
Process Instrumentation
(CH-423)

Maximum Marks: 60  
Credits: 03  
Duration: Three Hours

Answer all the questions.

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?

OR

(a') Explain the importance of instrumentation in process industries. Give a classification of instruments used in process industries. Explain with the help of diagrams where necessary.

1. (b) Write notes on standards and calibration used in instrumentation.

[07]

2. Write detailed notes on any one of the following mentioning their working principle, operating range, application etc. Draw neat and well labelled diagrams.
   (i) Pressure Measurement
   (ii) Temperature Measurement

[15]

3. With the help of a neat diagram explain briefly the working of Coriolis Flowmeter, Hygrometers (Resistive, Capacitive, Piezoelectric, Laminate, Hair), Psychrometer, Dew Point Meter, Induction Hydrometer, and Thermohydometer.

[15]

4. (a) Discuss briefly industrially important instruments for the measurement of gas composition and viscosity.

4. (b) Discuss strain gauge, fibre optic, ultrasonic, laser, and magnetic sensor technology used in chemical industry.

OR

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

[7]
Maximum Marks: 60
Credits: 04
Duration: Three Hours

2013-14
B.TEC IL (WINTER SEMESTER) EXAMINATION
(CHEMICAL ENGINEERING)
PROCESS HEAT TRANSFER
CH-466

Q.No.

1(a) How will you make good use of heat content of flue gases coming due to combustion of fuels? Explain briefly with line diagram.

1(b) Discuss with the help of simple diagram, the steam generation by a typical waste heat boiler.

1(c) Write down the correlations to calculate value of heat transfer coefficient in the following situations:
   i) Baffled vessel  ii) Spiral coil  iii) Fluid flow over a flat plate surface

2(a) Compare the pertinent merits of a Plate heat exchanger (with shell and tube heat exchanger) along with its applications in process industries. How will you calculate heat transfer coefficient and pressure drop for such heat exchanger?

2(b) Name the type of evaporator used in the following industries:
   i) Sugar, salt and Caustic soda  ii) Condensed milk
   iii) Fruit juices and Orange juices  iv) Rubber latex, Gelatin and Antibiotics
   v) Milk and Pharmaceuticals

2(c) What are important properties which affect the processing method of a solution in an evaporator? Enlist concisely.

OR

2'(a) Discuss the thermal significance of a fin in the process of heat transfer. Derive the rate equation of heat transfer from a fin and the efficiency of fin. Explain briefly the role of pertinent parameters which affect the efficiency of fin.

2'(b) A steel tube fitted with transverse circular steel fins of constant cross section, has the following specifications:
   Tube outer diameter, \(D_o = 54.00 \text{ mm} \)  Fin diameter, \(d_1 = 70.00 \text{ mm} \)
   Fin thickness, \(w = 2.0 \text{ mm} \)  Number of fins per meter = 230
   Determine the heat loss per meter of the tube when the surface temperature is 370K.

   

M.M.

[66]
[06]
[04]
[05]
[08]
[07]
and the temperature of surroundings at 280K. The heat transfer coefficient between gas and film is 30 W/m²K and the thermal conductivity of steel is 43 W/m K.

3(a) Draw the line diagram of boiling curve and discuss heat transfer coefficient of nucleate pool boiling and film boiling. Explain the experimental set-up to calculate boiling heat transfer coefficient of pure liquid.

3(b) Describe one of the passive methods of enhancement of heat transfer coefficient for boiling of liquids.

4 A packed bed of solid particles of density 2500 kg/m³, occupies a depth of 1.0 m in a vessel of cross sectional area of 0.01 m². The mass of solid in the bed is 59.0 kg and the surface-volume mean diameter of the particles is 1.0 mm. A liquid of density 800 kg/m³ and viscosity 0.002 P flows upward through the bed. Calculate

i) The voidage (volume fraction occupied by voids) of the bed.
ii) The pressure drop across the bed when the volume flow rate of liquid is 0.72 m³/h.
iii) The pressure drop across the bed when it becomes fluidized

OR

4(a') Air (ρ = 1.22 kg/m³, μ = 1.9 × 10⁻⁵ Pa.s) is flowing in a fixed bed of a diameter of 0.5 m and height of 2.5 m. The bed is packed with spherical particles of diameter of 10 mm. The void fraction is 0.38. The air flow rate is 0.5 kg/s. Calculate the pressure drop across the bed of particles.

4(b') Discuss briefly the heat transfer process in a fluidized bed and mention the correlations of heat transfer coefficient for the same.