B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025

(Branch : Chemical Engineering)

CM-7301 MASS TRANSFER EQUIPMENT DESIGN

Time   :   Three Hours

Maximum Marks :   70
Min. Pass Marks :   22

*Note   :   **Attempt any THREE questions. All questions carry equal marks. Draw neat sketch and assume suitable data wherever you required. Use of Design Data book is permitted in examination hall.***

1(a) Define maximum allowable pressure drop, turn down ration and Entrainment Flood of a sieve tray tower.

(b) The separation of a mixture of 60 mol per cent of A (MW = 78) and 40 mol per cent of B (MW = 92) is to be effected by distillation in a packed tower at atmospheric pressure, the feed being at its boiling point. The annual throughput of 50 000 tons per annum corresponds to 13 100 lb/hr [1.65 kg/s] after allowing for an annual shutdown. The rate of top product removal is to be 8000 lb/hr [1.01 kg/s] and the column is operated with a reflux of A ratio of 4:1. The top and bottom products should contain 95 per cent and 5 per cent benzene respectively. The average column conditions give rise to the following data :

Design a cross flow sieve tray for the system described above example, considering conditions on the top trays

- Average liquid density ρ_x = 43.3 lb/ft^3 [695 kg/m^3]
- Vapour density at top and bottom of column respectively = 0.168 and 0.182 lb/ft3 [=2.69 and 2.92 kg/m^3]
- Average liquid viscosity μ = 0.32 cP [3.2 x 10^{-4} N s/m^2]

Vapor liquid equilibrium data for Benzene and Toluene is presented in Table-1.

| Molar fraction of A in liquid, x_A	0	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0
Molar fraction of A in vapor, y_A	0	0.23	0.38	0.51	0.71	0.78	0.86	0.92	0.97	1.0

2(a) Explain the following principal for selection type of tray which used consider to their cost, capacity, operating range, efficiency and pressure drop.

(b) An industrial gas stream is available @ 2 kg/s from a cracking operation of NH_3 containing 72% H_2, 24% N_2 and 4% NH_3 by mole, at 202.65 kPa and 35°C.You have been asked to design a multistage countercurrent bubble cap absorber to remove NH_3 from the above stream with water as the scrubbing liquid. The liquid mass flow rate is limited to be 2 to 3.5 times of gas mass rate. NH_3 concentration should not be greater than 0.003 mg per m3 of the exit gas. Assumptions / design considerations :

Lean water-NH_3 system follows Henry's law and the corresponding equilibrium

- relation: $y* = 0.85x$ @30°C Isothermal gas absorption at room temperature (~30°C)
- Optimum adsorption factor (A) = 1.2 to 2
- Overall column efficiency = 70%
- Pressure drop per plate = 1 kPa
- Minimum liquid loading = 70% of expected maximum loading

P.T.O.

3(a) Explain various notations given in the *figure*.

$$h_{dc} = h_{\Delta p,dry} + h_{weir} + h_{crest} + h_{grad} + h_{du}$$
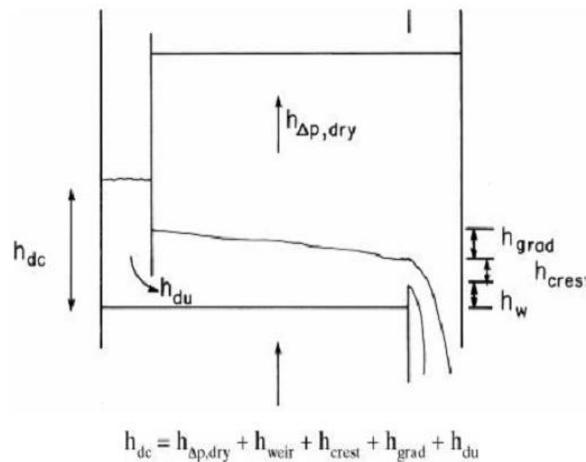
(b) A gas mixture containing 10 mol% SO_2 and 90 mol% air at 1 atm total pressure and 30°C is to be scrubbed with water to remove 97% of the SO_2 in a tower packed with 25 mm ceramic Raschig rings. The feed gas rate is 1500 kg per hour. Calculate :

(i) the minimum liquid rate,

(ii) the tower diameter if the liquid rate is 1.25 times the minimum and the tower operates at 70% of the flooding velocity.

For the calculation of the tower diameter the liquid may be assumed to have properties like water.

The Colburn-Drew volumetric mass transfer coefficient at the given conditions are :
$$k_x^{'}\bar{a} = 1.25 kmol/m^3 s\Delta x \qquad k_y^{'}\bar{a} = 0.075 kmol/m^3 s\Delta y$$

Solubility of SO_2 in H_2O at 20°C

Lb of SO_2/100 lb H_2O	0.02	0.05	0.10	0.15	0.20	0.30	0.50	0.70	1.0
Partial Pressure of SO_2 in Air, torr	0.5	1.2	3.2	5.8	8.5	14.1	26.0	39.0	59.0

4(a) You're a young engineer asked to design a column. Do you use trays, random packing or structured packing?

(b) Estimate the diameter of an RDC column to extract acetic acid from water with isopropyl ether for the conditions and data of Acetic acid is continuously extracted from a 3 wt% dilute solution in water with a solvent of isopropyl ether in a RDC column unit. The flow rates of the feed and solvent are 12,400 and 24,000 lbk, respectively. Assuming a residence time of 1.5 min in the mixer and a settling vessel capacity of 4 ga~min-ft2, estimate :

(i) Diameter and height of the mixing vessel, assuming HI DT = 1,

(ii) Agitator horsepower for the mixing vessel,

(iii) Diameter and length of the settling vessel, assuming LIDT = 4, and

(iv) Residence time in minutes in the settling vessel.

5(a) Explain the factors influencing extraction column design.

(b) Under what conditions is a cascade of mixer-settler units probably the best choice of extraction equipment?

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B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025
(Branch : Chemical Engineering)

CM-7302 MODELLING AND SIMULATION

Time   :   Three Hours

Maximum Marks   :   70
Min. Pass Marks   :   22

Note : Attempt any five questions. All questions carry equal marks. Draw neat sketch and assume suitable data wherever you require.

1(a) Explain any four fundamental laws used in modeling.

 (b) Discuss different methods of model evaluation.

2(a) What is the difference between verification and validation?

 (b) Explain application and working of any one commercial simulator used in chemical industries.

3(a) What is the main difference between the lumped parameter model and the distributed parameter model?

 (b) Consider a conical receiver shown in *fig.1*. The inlet and outlet liquid volumetric flow rates are F1 and F2, respectively.

  (i)   Develop the model equation with necessary assumption(s) with respect to the liquid height h.
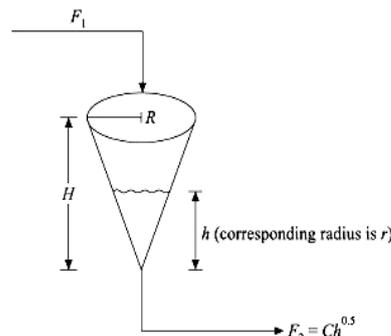 (ii) What type of mathematical model is this?

Fig.1 : A Conical Tank

4   Derive the dynamic mass balance equations for the following case (*fig.2* represents Case 2). Assume : (i) a linear relationship between liquid level and flow rate through the outlet valve, and (ii) constant liquid density.
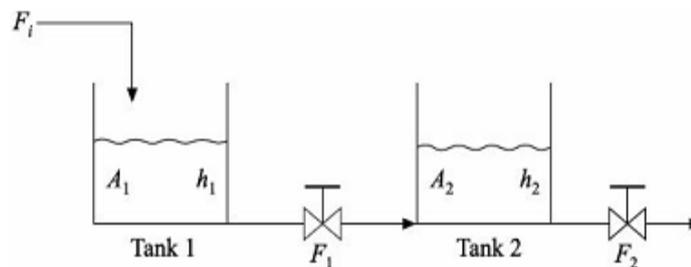

Fig.2 : Two Interacting Tanks in Series (Case 2)

P.T.O.

5 Develop a mathematical model for an ideal distillation column considering two partially vaporized feed streams. one is fed on 6th and other is on 10th tray. Make suitable assumptions.

6(a) Distinguish among independent variables, dependent variables and parameters with suitable examples.

(b) Develop model equations for isothermal CSTR. The reaction is assumed to be irreversible and of first order. $A \xrightarrow{k} B$.

As shown in **fig.3**, the feed enters the reactor with volumetric rate F_f (m³/s), density ρ_f (kg/m³), and concentration C_{Af} (mole/m³). The output comes out of the reactor at volumetric rate F_o, density ρ_0 and concentration C_{Ao} (mole/m³) and C_{Bo} (mole/m³).
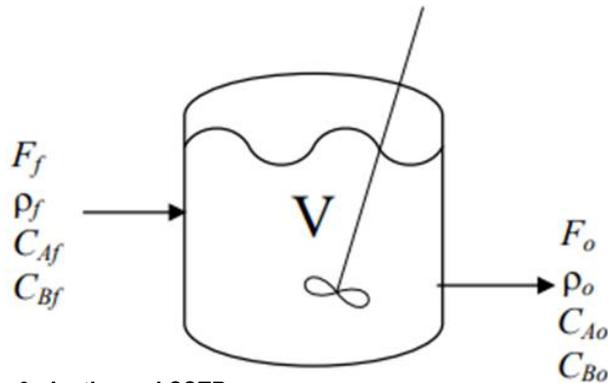

Fig.3 : Isothermal CSTR

7(a) What does "Steady state and Dynamic" means?

(b) Consider the LPG vaporizer as shown in **fig.4**. Liquefied petroleum gas (LPG) is fed into a pressurized tank to hold the liquid level in the tank. We will assume that LPG is a pure component : propane. Develop the model equations used to describe the boiling rate should be physically reasonable and mathematically convenient for solution.
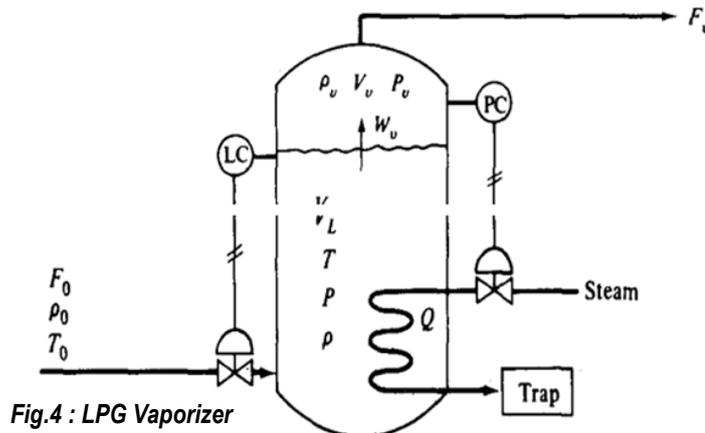

Fig.4 : LPG Vaporizer

8(a) Describe classification of mathematical modeling based on state of the process.

(b) The liquid in a jacketed, non isothermal CSTR is stirred by an agitator whose mass is significant compared with the reaction mass. The mass of the reactor wall and the mass of the jacket wall are also significant. Write the energy equations for the system. Neglect radial temperature gradients in the agitator, reactor wall, and jacket.

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B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025

(Branch : Chemical Engineering)

CM-7333 (EL-III) FETRILIZER TECHNOLOGY

Time : Three Hours

*Maximum Marks : **70***
*Min. Pass Marks : **22***

Note : Attempt any five questions. Each question carries equal marks.

1(a) Describe in detail the classification of plant Nutrients.   *07*

 (b) Describe in detail the status of Fertilizer Industries in India.   *07*

2(a) What do you mean by Fertilizer? How it helps in plant growth and crop production?   *07*

 (b) Mention in detail the different types of feed stock used for the manufacture of fertilizer.   *07*

3(a) Describe in detail the process for the manufacture of Urea along with flow sheet.   *07*

 (b) Discuss the major engineering problems and economics of the process mentioned in 3(a).   *07*

4(a) Describe in detail the process for the manufacture of ammonium sulphate along with its flow sheet.   *07*

 (b) Discuss the major engineering problems and economics of the process mentioned in 4(a).   *07*

5(a) Describe in detail about mixed fertilizer. Give its advantages and disadvantages.   *07*

 (b) Mention about the safety rules and regulation related to the transportation, handling and storage of fertilizers.   *07*

6(a) Discuss in detail along with flow sheet the process for the manufacture of single superphosphate.   *07*

 (b) Discuss the major engineering problems and economics of the process mentioned in 6(a).   *07*

7(a) Describe in detail the process for the manufacture of synthesis gas.   *07*

 (b) Discuss the major engineering problems and economics of the process mentioned in 7(a).   *07*

8(a) Discuss in detail about the corrosion problem related to fertilizer industries.   *07*

 (b) Give a comparison between Bio fertilizer and synthetic fertilizer.   *07*

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B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025

(Branch : Chemical Engineering)

CM-7334 (EL-III) PATROLEUM PROCESS TECHNOLOGY

Time : Three Hours

Maximum Marks : 70
Min. Pass Marks : 22

Note : **Attempt any five questions. All questions carry equal marks. Draw neat and labeled diagram whenever necessary.**

1(a) Describe in detail the different theories related to the formation of crude oil.   **07**

  (b) Mention the various hydrocarbon series that are present in crude oil.   **07**

2(a) Discuss about the various types of impurities present in crude oil.   **07**

  (b) Explain in detail the working principal of ASTM apparatus.   **07**

3(a) Mention the physical and chemical characteristics of diesel and gasoline.   **07**

  (b) What do you mean by pre treatment of crude oil? Explain in detail.   **07**

4(a) Give a comparison between atmospheric distillation and vacuum distillation process.   **07**

  (b) Discuss the mechanism of thermal cracking process.   **07**

5(a) Describe in detail about catalytic reforming along with its advantages and disadvantages.   **07**

  (b) Give a comparison between thermal cracking and catalytic cracking.   **07**

6(a) Discuss the mechanism of alkylation process.   **07**

  (b) Describe in detail the process for the manufacture of air blown asphalt.   **07**

7(a) Give a comparison between sweetening and desulphurization process.   **07**

  (b) How are lubricating oil classified? Explain in detail.   **07**

8(a) Mention the types of gaseous hydrocarbons obtained during the processing of crude oil in refinery.   **07**

  (b) Describe in detail the environmental issues related to the handling and storage of refineries products.   **07**

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B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025

(Branch : Chemical Engineering)

CM-7335 (EL-III) SUSTAINABILITY ENGINEERING

Time : Three Hours

Maximum Marks : 70
Min. Pass Marks : 22

Note : Attempt any five questions. Each question carries equal marks.

1(a) What do you mean by sustainable development? Discuss the different model of **07** sustainability.

(b) What are the challenges for sustainable development? Discuss in detail. **07**

2(a) Discuss the relationship between zero waste and three R concepts. **07**

(b) What are the various sources of solid waste? Explain different methods of solid waste **07** management.

3(a) What is biomimicry? List any five products developed bases on biomimics. **07**

(b) Elaborate on the scope and goal of Life cycle Assessment with an example. **07**

4(a) Green buildings are essential for environmental sustainability. Justify by giving any five **07** key features of green building.

(b) Explain the concept of green engineering. **07**

5(a) Justify the necessity of developing non conventional source of energy. **07**

(b) Electric vehicle (EV) being run on electricity is claimed as emission-free. Still, the fact that **07** significant share of Electrical Energy produced across the globe is of thermal origin put question marks on the emission-free claim. Justify this statement.

6(a) How would you take initiatives in conducting your college fest, so that is remains an **07** environmental sustainable one?

(b) Discuss the significance of carbon footprint. Suggest some methods for reducing the **07** carbon footprint of your house.

7(a) Suggest ways to reduce the emission of Greenhouse gases. How each option benefits the **07** environment?

(b) Explain the reason as to why an organization may choose to implement ISO 14000 series **07** of standard.

8 Write short notes on **any three** : **14**

   (i) Carbon trading
   (ii) GRIHA rating
   (iii) Sustainable cities
   (iv) Environment management system
   (v) Biomass to energy conversion process

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B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025

(Branch : Chemical Engineering)

CM-7341 (EL-IV) ENERGY MANAGEMENT

Time   :   Three Hours

Maximum Marks : 70
Min. Pass Marks : 22

Note : Attempt any five questions. Each question carries equal marks. Draw neat sketch and assume suitable data wherever required.

1(a) Outline the key steps for implementing energy management in an organization and examine potential energy efficiency opportunities in chemical processes. **07**

(b) What are the essential metrics used for benchmarking energy performance? **07**

2 Describe the standard format for an energy audit report and list the key instruments used in energy auditing along with their applications. **14**

3(a) What is the fundamental principle behind CUSUM analysis in energy monitoring? **07**

(b) What metrics are commonly used to track energy consumption trends? How can organizations set realistic energy performance targets? **07**

4(a) What are the primary objectives of the UNFCCC in global energy management? **07**

(b) How does the Kyoto Protocol influence global energy policies and sustainability efforts? **07**

5(a) What are the primary sources of waste heat in industrial processes? How can waste heat recovery improve overall energy efficiency **07**

(b) Discuss the primary energy efficiency strategies for HVAC systems? **07**

6(a) What are the most effective strategies for reducing energy losses in electrical utilities? **07**

(b) Provide a concise overview of economic thickness of insulation, including its definition, classification, and practical applications. **07**

7(a) What is the role of a grid diagram in visualizing energy flow and distribution? **07**

(b) Analyze the various types of refractories and categorize them according to their chemical composition. **07**

8(a) Explain the core principle of Pinch Technology and discuss its advantages in optimizing the process for energy efficiency. **07**

(b) What is the significance of Composite Curves in pinch analysis? **07**

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Total No. of Questions : **08**   Roll No. : 0701...................................

B.Tech SEVENTH SEMESTER EXAMINATION JUNE-2025
(Branch : Chemical Engineering)

CM-7342 (EL-IV) PROCESS SAFETY AND HAZARD MANAGEMENT

Time : Three Hours

*Maximum Marks : **70***
*Min. Pass Marks : **22***

Note : Attempt any five questions. All questions carry equal marks. Draw neat and labelled diagram whenever necessary.

1(a) Explain in detail the term process safety and hazard management.   **07**

  (b) Mention the essential features of a successful training programme.   **07**

2(a) Discuss and explain the term mechanical hazard and electrical hazard.   **07**

  (b) Mention the salient features of professional ethics related to chemical engineering.   **07**

3(a) Discuss in detail the Gaussian distribution system representing the biological response to **07** exposure of toxicants.

  (b) Discuss the term HAZOP and HAZON studies along with its physical significance.   **07**

4(a) Describe in detail the probability theory that correlates the equipment failure in process **07** plant.

  (b) Discuss in detail the steps involved in failure data analysis.   **07**

5(a) Discuss the procedure for calculating chemical explosion index.   **07**

  (b) Mention the salient features of fault tree analysis.   **07**

6(a) Define the term limiting oxygen concentration and Minimum Ignition Energy (MIE).   **07**

  (b) Discuss in detail about relief system.   **07**

7(a) Give a comparison between mechanical explosion and chemical explosion.   **07**

  (b) Describe in detail about shock wave propagation technique.   **07**

8(a) Discuss in detail the salient features of quantitative risk analysis.   **07**

  (b) Discuss in detail about the cause and magnitude of accident that took place at flix borough **07** in England.

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