2023-24

III YEAR B.TECH. (AUTUMN SEMESTER) EXAMINATION

PETROCHEMICAL ENGINEERING

ENGINEERING MATERIALS

ACA-3110

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

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

Q.No.	Question	CO	M.M.
1	Answer any **SIX** of the followings:		[2.5×6]
	(a) Define anisotropy. Explain the cooling curves of crystalline and amorphous materials.	(CO1)	
	(b) Distinguish between the orthorhombic and rhombohedral crystal structure with the help of suitable sketch.	(CO1)	
	(c) Calculate the density of Au from the following data: Crystal Structure = FCC Atomic radius = 1.35 Å Atomic weight = 196.96 g/mol Avogadro's number = 6.023×10^{23}	(CO1)	
	(d) Determine the packing efficiency of BCC crystal structure.	(CO1)	
	(e) Determine the Miller Indices of a plane which is parallel to y-axis and cuts intercepts of 3 and 2, respectively along x and z axes.	(CO1)	
	(f) Calculate the interplanar distance for orthorhombic lattice with a = 2.8 Å, b = 3.6 Å and c = 4.2 Å for the plane (121).	(CO1)	
	(g) Write the advantages of XRD method for the determination of crystal structures.	(CO1)	
	(h) Distinguish between Schottky and Frenkel Defects.	(CO1)	
2 (a)	What are stainless steels? How are they classified? Give the general composition, characteristic properties, applications and examples of austenitic stainless steels.	(CO2)	[06]
2 (b)	Discuss **ANY THREE** of the followings: (i) Castability (ii) Malleable cast iron	(CO2)	[03×3]

contd....2o

(iii) Thermogram for decomposition of pure calcium oxalate monohydrate ($CaC_2O_4.H_2O$)
(iv) SEM imaging
(v) Plain carbon steel

3 (a) Draw Fe-C phase equilibrium diagram and show the following from the diagram. (CO3) [6]
(i) Solid phases
(ii) Eutectoid, hypereutectoid and hypoeutectoid steel
(iii) Invariant reactions

3 (b) Discuss **any two** of the followings: (CO3) [4.5x2]
(i) Annealing
(ii) Phase changes in the pure iron
(iii) Pb-Sn phase diagram

4(a) Answer any **THREE** of the followings: [2.5×3]
(i) Explain the mechanism of the reactions at surface. (CO4)
(ii) Discuss the influence of temperature and pressure on the adsorption of gases on solids. (CO4)
(iii) Write the assumptions for Langmuir adsorption isotherm. (CO4)
(iv) Explain the phenomena of Brownian movement and Tyndall effect observed in colloids. (CO4)

4(b) Answer any **ONE** of the followings: [7.5]
(j) The data below are for the adsorption of CO on charcoal at 273 K. Confirm that they fit the Langmuir isotherm, and find the constant K and the volume corresponding to complete coverage. (CO4)

p (Torr)	100	200	300	400	500	600	700
V (cm^3)	10.2	18.6	25.5	31.5	36.9	41.6	46.1

(ii) Derive the following equation for BET adsorption isotherm (CO4)

$$\frac{V}{V_{mono}} = \frac{cz}{(1-z)(1-(1-c)z)}$$

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2023-24

B.TECH. (AUTUMN SEMESTER) EXAMINATION
CHEMICAL/PETROCHEMICAL ENGINEERING
MASS TRANSFER OPERATIONS
CHC3080/PKC3050

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all the questions.

Q No	Question	Marks	CO covered
1(a)	Define diffusive flux and convective flux of mass transfer. Show that the molar diffusive and convective fluxes are related as $N_i = x_i \sum_i N_i + J_i$ Hence show that $\sum_i J_i = 0$	[06]	CO-1
1(b)	At a particular section of an equipment for absorption of a solute A in a liquid, the bulk gas phase contains 9.5 mol% A and the liquid contains 2 mol% of A. The gas-film coefficient is $k_y = 10$ kmol/(h)(m^2)(Δy) and 60% of the mass transfer resistance occurs in the liquid-film. The equilibrium is described by Henry's law, $y_A = 0.85x_A$. Calculate (a) the overall mass transfer coefficient, K_x; (b) the molar flux of A; and (c) the interfacial concentrations of the solute, x_{Ai} and y_{Ai}.	[09]	CO-1
	OR		
1'(a)	Penetration theory interprets the mass transfer rate at the interface as given by: $N_{Ax}\|_{x=0} = (c_{Ai} - c_{Ab})\sqrt{\frac{D_{AB}}{\pi t}}$ Using Danckwerts' age distribution function $\phi(t) = se^{-st}$, show that the Danckwets' surface renewal model gives the average liquid side mass transfer coefficient as: $k_{L,av} = \sqrt{sD_{AB}}$; where s is the surface renewal rate.	[06]	CO-1
1'(b)	The gas-phase mass transfer coefficient for the evaporation of a drop of ethyl alcohol in a stream of air at 300 K and 1.2 bar pressure is $k_G = 2.4\times10^{-6}$ kmol/s·m^2·mm Hg. Calculate the value of the mass transfer coefficient if the driving force is expressed in terms of difference in: (i) mole fraction of alcohol in the gas phase, (ii) concentration of alcohol in kmol/m^3. Also calculate F_G.	[09]	CO-1

Contd.... 2.

If the diffusivity of ethyl alcohol in air is 0.102 cm^2/s at 0 °C and 1 atm., estimate the thickness of the stagnant gas-film. Vapor pressure of alcohol = 0.0877 bar at 300 K.

2 A packed tower 4.0 m tall is used to absorb ethyl alcohol from an inert gas by 90 kmol/h of pure water at 30 °C and 1 atm. The total gas stream flow rate of 100 kmol/h contains 2.0 mol% alcohol and the exit concentration is 0.2 mol%. The equilibrium relationship is $y = 0.68x$. Using the analytical equations, calculate the number of theoretical stages, N, number of overall gas transfer unit, N_{tOG}, height of overall gas transfer unit, H_{tOG}, and height equivalent to theoretical plate, HETP. **[15]** **CO-2**

OR

2' A relatively nonvolatile hydrocarbon oil contains 4.0 mol% propane and is being stripped by direct superheated steam in a stripping tray tower to reduce propane content to 0.2 mol%. A total of 11.42 kmol of direct steam is used for 300 kmol of total entering liquid. Under the prevailing conditions in the tower, the vapor liquid equilibria is described as $y = 25x$. Determine the number of theoretical staged required both graphically and using Kremser's equation. **[15]** **CO-2**

3(a) A mixture of air and benzene vapor at 800 mmHg has a dry bulb temperature and wet bulb temperature as 50 °C and 31 °C respectively. Determine the absolute humidity of the mixture in kg/kg dry air. The psychrometric ratio of benzene vapor-air system is 1.72 kJ/kg°C and the latent heat of vaporization of benzene at 30 °C is 428.02 kJ/kg. The vapor pressure of benzene is given by **[05]** **CO-3**

$$\log p^*[mmHg] = 8.15 - \frac{1842.2}{T[K]}$$

3(b) A cooling tower receives warm water at 43 °C at a mass flow rate of 7000 $kg/m^2 \cdot h$. A cooling range of 13 °C is achieved by countercurrent contact with air. The air enters at a rate of 4200 $kg/m^2 \cdot h$ at a dry bulb temperature of 31 °C and a humidity of 0.01516 kg/kg DA. The overall volumetric mass transfer coefficient is $K_Y a = 250$ $kg/m^3 \cdot h \cdot \Delta Y'$. Determine the height of the packing. **[10]** **CO-3**

4(a) A batch of wet solid was dried on a tray dryer using constant drying conditions and a thickness of material on the tray of 25.4 mm. Only the top surface was exposed. The drying rate during the constant-rate period was N_c = 2.05 kg water/$h \cdot m^2$. The ratio S_S / A used was 24.4 kg dry solid/m^2 exposed surface. The initial free moisture was X_1 = 0.55 and the critical moisture content X_c = 0.22 kg free moisture/kg dry solid. Calculate the time **[09]** **CO-4**

Contd....3.

required to dry the batch of this material from $X_1 = 0.45$ to $X_2 = 0.30$ using the same drying conditions but a thickness of 50.8 mm, with drying from both the top and bottom surfaces.

4(b) A salt solution weighing 10000 kg with 30 wt% is cooled to 20 °C. the salt crystallizes as the dehydrate. If 3% of the total weight of the solution is lost by evaporation of water in cooling, Calculate the yield of $Na_2CO_3.10H_2O$ crystals. The solubility is 21 kg Na_2CO_3/100 kg of total water. **[06]** **CO-4**

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contd...4.

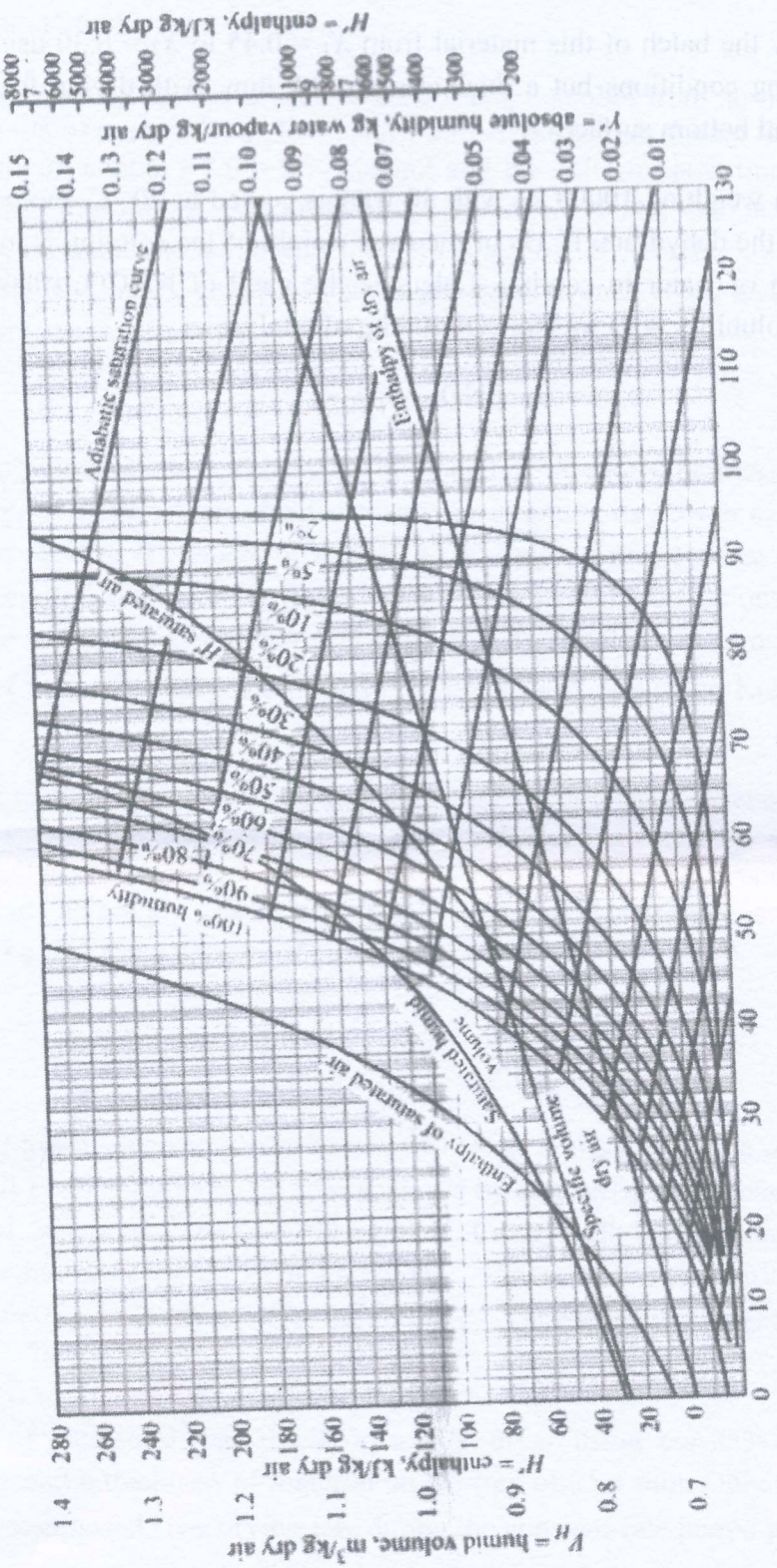


Figure 10.6 (a) Psychrometric chart for the air–water system at 1 atm total pressure.

2023-2024

B.TECH. (AUTUMN SEMESTER) EXAMINATION

MEH-3450: ENGINEERING ECONOMY & MANAGEMENT

(COMPUTER/ARTIFICIAL INTELLIGENCE/CHEMICAL/PETROCHEMICAL ENGINEERING AND FOOD TECHNOLOGY)

Maximum Marks: 60 **Duration: Two Hours**

All questions are compulsory.
Assume data suitably, if required.

1(a) Write one practical implication of the Equilibrium Point on the supply-demand curve. [CO1] [01]

1(b) On the Cost-Revenue Curve, show the regions of Profit and Loss. [CO1] [01]

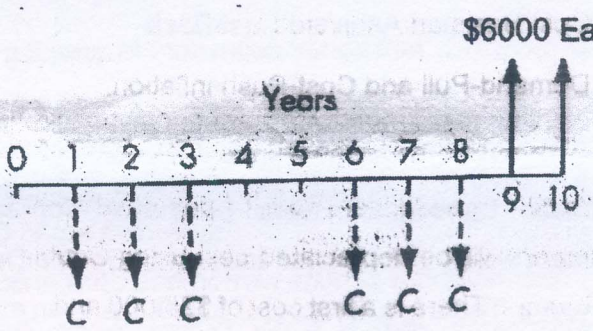
1(c) Write in brief, how the equilibrium point changes if variable cost is decreased. [CO1] [02]

OR

1(c') Differentiate between Monopoly and Oligopoly. [CO1] [02]

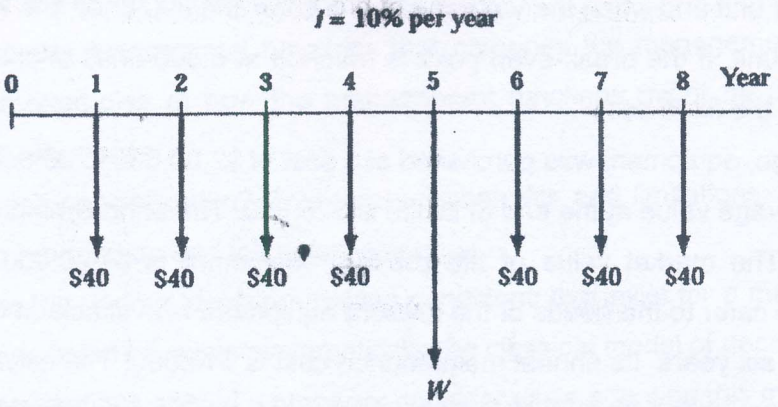
1(d) Differentiate between Nominal and Effective Interest Rates. [CO1] [02]

1(e) From the cash flow diagram, find the value of C (in $) that will establish the economic equivalence between the deposit series and the withdrawal series at an interest rate of 8% compounded annually. [CO1] [04]



OR

1(e') For the cash flow diagram shown, determine the value of *W* that will render the equivalent future worth in 8 years equal to $500 at an interest rate of 10% per year. [CO1] [04]



Contd....2

1(f) Two alternative machines are being considered for a manufacturing process. Machine 'A' has a first cost of $75,200 and its salvage value at the end of 6 years of estimated service life is $21,000. The operating costs of this machine are estimated to be $6,800 per year. Extra income taxes are estimated at $2,400 per year. Machine 'B' has a first cost of $44,000 and its estimated salvage value at the end of 6 years' of service is estimated to be negligible. The annual operating costs will be $11,500. Compare these two alternatives by the present worth method at i=13% per year. [CO1] [05]

OR

1(f') The purchase of a truck with an operator's platform on a telescoping hydraulic boom will reduce labour costs for sign installations by $15,000 per year. The price of the boom truck is $ 93,000 and its operating costs will exceed those of present equipment by $250 per month. The resale value is expected to be $18,000 in 8 years. Should the boom truck be purchased when the current available interest rate is 7%? [CO1] [05]

2(a) Define "Profitability Index" in the context of B/C Analysis. [CO2] [01]

2(b) Define Debt-Equity Ratio. [CO2] [01]

2(c) Differentiate between Cost Basis and Adjusted Cost Basis. [CO2] [01]

2(c) Differentiate between Demand-Pull and Cost-Push inflation. [CO2] [02]

2(d) On the Cost-Volume curve, how the breakeven point can be lowered? [CO2] [02]

2(e) Underwater electroacoustic transducers were purchased for use in SONAR applications. The equipment will be depreciated best using Double Declining Balance Method over a life of 12 years. There is a first cost of $25,000 and an estimated salvage of $2500. Calculate the depreciation and book value for 1st & 4th years. [CO2] [03]

OR

2(e') For a manufacturing firm, when the volume of production is 3,000 units, the average cost is $4 per unit and when the volume of production is 4,000 units, the average cost is $3.50 per unit. If the break-even point is reached at 5,000 units of production and sale, find out the fixed cost. [CO2] [03]

2(f) Two years ago, equipment was purchased at a cost of $2,00,000 to be useful for eight years. Its salvage value at the end of its life is $25,000. The annual maintenance cost is $25,000. The market value of the present equipment is $1,20,000. Now, new equipment to cater to the needs of the present equipment is available at $1,50,000 to be useful for six years. Its annual maintenance cost is $14,000. The salvage value of the new equipment is $20,000. Using an interest rate of 12%, find whether it is worth replacing the present equipment with the new equipment. [CO2] [05]

OR

Contd.... 3.

2(f') In the past, the Afram Foundation has awarded many grants to improve the living and medical conditions of people in war-torn and poverty-stricken countries throughout the world. In a proposal for the foundation's board of directors to construct a new hospital and medical clinic complex in a deprived central African country, the project manager has developed some estimates. These are developed in a manner that does not have a major negative effect on prime agricultural land or living areas for citizens. [CO2] [05]

Award amount: $20 million (end of) first year, decreasing by $5 million per year for 3 additional years; local government will fund during the first year only.

Annual costs: $2 million per year for 10 years, as proposed.

Benefits: Reduction of $8 million per year in health-related expenses for citizens.

Disbenefits: $0.6 million per year for the removal of arable land and commercial districts.

Use the conventional and modified B/C methods to determine if this grant proposal is economically justified over a 10-year study period. The foundation's discount rate is 6% per year.

[CO3] [1x3]

3(a) *Fill in the blanks*

i) The Herzberg theory of motivation states that.....

ii) .....is a statement of the organization's fundamental purpose.

iii) Power granted through the organizational hierarchy is called .....

[CO3] [2x2]

3(b) *Answer any **TWO** of the following:*

i) Draw and define wide and narrow span of management.

ii) Define organizational goals? What is their importance in the management process?

iii) Differentiate between line and staff authority with suitable examples.

[CO3] [4x2]

3(c) *Answer any **TWO** of the following:*

i) What are the fundamental functions that comprise the management process? Describe examples of how the management functions might be performed in different sequences.

ii) What is job specialization? Enumerate its benefits and limitations. Differentiate between job rotation and job enlargement.

iii) What are the various decision-making conditions that exist for a manager while taking a decision? Explain systematically the classical model of decision-making. What assumptions should a manager consider while adopting this model?

Contd ....4.

4(a) *Fill in the blanks:* [CO4] [1x3]

i) A list of important managerial positions in the occupation, who occupies it, how long he/she will remain in position and who is/will be a qualified replacement is known as .....

ii) The four P's of marketing mix are .....

iii) .....is a business that transcends national boundaries and is not committed to a single host country.

4(b) *Answer any **TWO** of the following:* [CO4] [2x2]

i) Differentiate between Q/R inventory system and periodic inventory system.

ii) Demand for part number 1012 was 210 in January, 100 in February and 150 in March. The forecast for January was 140 units. With a smoothing constant of 0.30 and using first order exponential smoothing, what is the April forecast?

iii) What is a "Market"? List the types of markets that are used by sellers and buyers in a modern exchange economy.

4(c) *Answer any **TWO** of the following:* [CO4] [4x2]

i) What procedures do the human resource managers adopt while planning for human resources? How are the forecast and human resource demand and supply matched? Explain.

ii) Describe the four basic levels of international business activity. Do you think any organization will achieve the fourth level? Why?

iii) Define Quality. Discuss the two aspects of quality. Name some quality control tools and explain any one of them in detail.

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2023-24

B.TECH. (EVEN SEMESTER) EXAMINATION
PETROCHEMICAL ENGG.
PETROLEUM REFINING PROCESSES
PKC-3010

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all the Questions.

Q.No.	Question	M.M.	COs
1(a)	Explain with the help of neat sketch, the process of atmospheric distillation of crude oil with reference to feed temperature, pressure, and products obtained.	[05]	[CO1]
(b)	Give the significance of Dual gasification Flexicoking process. Explain with the help of neat sketch Dual gasification Flexicoking Process. Mention the reactions in the gasifier, reactor and burner.	[10]	[CO1]
	OR		
(b')	Answer the following: (i) What are the various types of refluxes used in crude oil distillation? (ii) What are the process variables affecting the yield and quality of the product in visbreaking process? (iii) Differentiate between thermal cracking processes and catalytic cracking processes	[3+4+3]	[CO1]
2(a)	Discuss the technological aspects and principles of operation of FCC with reference to reactor design.	[04]	[CO2]
(b)	Discuss in brief Hydrocracking Process with special reference to feedstock, catalyst and product pattern and compare it with catalytic cracking.	[06]	[CO2]

contd ... 2.

OR

(b') Describe with the help of reactions and process flowsheet desulfurization of Naphtha. Mention process variables and catalyst used in the process. [CO2]

(c) Write in brief about any two of the following: [2.5x2=5] [CO2]

(i) Deep catalytic cracking

(ii) Hydrotreating processes

(iii) Significance of denitrogenation and desulfurisation of feedstock in hydrocracking process.

3(a) What are the main reactions that occurs during catalytic reforming processes? Explain in brief the significance of each reaction in reforming process. [05] [CO3]

(b) Explain in brief any two of the following: [5x2=10] [CO3]

a) Significance of Catalytic Polymerization processes in petroleum Industry. Mention any two commercial catalytic polymerization processes.

b) Catalytic Isomerization with emphasis on UOP butane isomerization process with respect to catalyst and significance

c) Significance of Alkylation process. Mention atleast three merits of each HF and Sulfuric acid alkylation processes

4(a) What are the desirable properties of Lubricating oils and mention the role and importance of each processing step employed for the production of Lube Oil Base Stock (LOBS). [05] [CO4]

4(b) What are the main steps involved in wax deoiling operation? Why MIBK is preferred over MEK as deoiling solvent? [05] [CO4]

(c) Explain in brief solvent extraction process for the manufacture of LOBS [05] [CO4]

Contd.... 3.

with reference to solvents used and comparison of different solvents used in this process.

OR

(c') Explain in brief solvent deasphalting process for the manufacture of LOBS. [CO4]

2023-2024 Code:6628

B.Tech, Odd Semester Examination

Petrochemical Engineering

PKC 3030 (Heat Transfer Operations)

Credits: 04

Maximum Marks: 60 **Time: 2 Hours**

Answer all the questions

Assume suitable data if missing

Notations used have their usual meanings

1. a) State and derive Fourier's Law of conductive heat transfer for one dimensional system. CO1 MM 3

b) The heat flux (from outside to inside) across an insulating wall with thermal conductivity (k) is 0.04 W/m. K and thickness 0.16 m is 10 W/m^2 K. The temperature of the inside wall is maintained at -5 °C. Calculate the outside temperature of the wall. CO1 MM 4

c) The wall of a cold storage consists of three layers: an outer layer of ordinary bricks of 25 cm thick; a middle layer of cork of 10 cm thick and an inner layer of cement of 6 cm thick. The temperature of the outer surface of the wall is 30°C and that of inner surface is 15°C. Given: Thermal conductivity of brick is 0.7 W/m .°C, cork is 0.043 W/m .°C and cement is 0.72 W/m .°C respectively.

contd...2

Calculate:

i) The steady state rate of heat gain per unit area of the wall.

ii) The temperature at the interface of the composite wall.

iii) The percentage of the total heat transfer resistance offered by individual layers.

CO1 MM 8

OR

c') A furnace with a steel door (1.5 m height and 1 m wide) having a inner lining of an insulating material, is maintained at 65 °C and loses heat to the ambient at 25 °C. Calculate the rate of heat loss at steady state.

The properties of air at average film temperature: Pr no. 0.695; thermal conductivity (k) is 0.028 W/m. °C and v is 1.85×10^{-5} m^2/s.

Charchill & Chu equation for vertical plate can be used. CO1 MM 8

2. a) Explain briefly the different stages of boiling curve. CO2 MM 3

b) A steel ball (density 8000 Kg/m^3, heat capacity 450 J/ Kg. K) of 50 mm diameter is cooled by exposing it to air stream at 320 K. Estimate the time needed to cool the steel ball from 1120 K to 520 K. The convective heat transfer coefficient is 100 $W/m^2.K$. CO2 MM 5

c) A hot oil entering a stirred vessel (well mixed) is cooled by passing cold water through a jacket around the vessel. Mass flow rate of the hot oil is 0.25 kg/s, sp heat of oil is 6000 J/ Kg. K, mass flow rate of cold water is 0.4 Kg/s and sp heat of cold water is 4184 J/ Kg. K. The inlet and outlet temperatures of the hot oil are 150 °C and 100 °C respectively. The inlet temperature of

Contd....3

cold water is 20 °C. The overall heat transfer coefficient is 500 W/m^2 .K. Calculate the heat transfer area. CO2 MM 7

OR

c') Hot liquid is flowing at a velocity of 2 m/s through a metallic pipe having inner diameter of 3.5 cm and length 20 m. The temperature at the inlet of the pipe is 90 °C. Calculate heat transfer coefficient.

The data is given for liquid at 90 °C:

Density 950 Kg/m^3; sp heat 4.23 KJ/Kg. °C; viscosity 2.55x 10^{-4} Kg/m.s and thermal conductivity (k) 1.163 W/m. °C. CO2 MM 7

3. a) State and derive the Stefan- Boltzman law of radiation.

CO3 MM 3

b) An insulated cylindrical pipe of 0.2 m dia has a surface temperature of 45°C. It is exposed to black body surroundings at 25°C. Find the percentage contribution from radiation to total heat transfer rate to the surroundings.

Data given: The emissivity and absorptivity of insulation surface are 0.96 and 0.93 respectively. Convective heat transfer coefficient of outside the insulation surface is 3.25 W/m^2 .K. CO3 MM 5

c) In a counter-flow double pipe heat exchanger, oil (mass flow rate 2 Kg/s, sp heat capacity 21 KJ/Kg °C) is cooled from 90 °C to 40 °C by water (mass flow rate 1Kg/s, sp heat capacity 4.21 KJ/Kg. °C) which enters the inner tube at 10 °C (radius of the inner tube is 3 cm and its length is 5 m). Calculate overall heat transfer coefficient based on the inner radius by

Contd....4.

neglecting wall resistances. CO3 MM 7

OR

c') Water at the rate of 6800 Kg/h is to be heated from 311K to 328 K in a double pipe heat exchanger by using another water stream in the annulus. The hot water enters the annulus counter currently at the rate of 3400 Kg/h. Calculate the length of heat exchanger.

Given: Overall heat transfer coeff.is 1420 W/ m^2 K; heat capacity of water is 4180 J/ kg. K and outside diameter of inner pipe is 0.115 m. CO3 MM 7

4. a) Compare advantages and limitations of forward and backward feed modes of evaporator.

CO4 MM 3

b) An aqueous sodium chloride solution (10 wt %) is fed into a single effect evaporator at a rate of 10,000 Kg/ h and it is concentrated to 20 wt%. The rate of consumption of steam in the evaporation is 8000 Kg/h. Find the evaporator capacity and steam economy. CO4 MM 4

c) A single effect vertical short tube evaporator is used to concentrate syrup from 10% to 40% solids at the rate of 2000 kg of feed per hour. Feed enters at 30 °C and a reduced pressure of 0.33 Kg/ cm^2 is maintained in the vapour space. At this pressure liquor boils at 75 °C. Saturated steam at 115 °C is supplied to the steam chest. No subcooling of condensate occurs. Calculate the stem requirement and the number of tubes (0.0254, 16 BWG) if the height of calandria is 1.5 m.

contd... 5.

Given: sp. heat of liquor 0.946 Kcal/ Kg .°C, latent heat of steam at 0.33Kg/ cm^2 is 556.5 Kcal/Kg, Boiling pt of water at the same pressure is 345 K, Overall heat transfer Coefficient is 2150 Kcal/h.m^2. °C. [CO4 MM 8]

OR

c') An aqueous solution is concentrated from 5 wt% to 20 wt % in a single effect evaporator. The feed enters the evaporator at a rate of 10 kg/s at 325 K. Steam is available at a saturation pressure of 1.3 bar. The pressure in the vapour space of the evaporator is 0.13 bar and corresponding saturation temperature is 380 K. The overall heat transfer coefficient is 5000W/ m^2 K. Calculate i) Steam economy, ii) Heat transfer area of the evaporator.

Given: Enthalpy of saturated steam 2200 KJ/ Kg ; Enthalpy of feed 8 KJ/ Kg ; Enthalpy of concentrated liquor 400 KJ/ Kg ; Heat of vaporization of saturated steam 2000 KJ/ Kg . CO4 MM 8

Paper Code: 6630

2023-24
B.TECH. (ODD SEMESTER) EXAMINATION
(PETROCHEMICAL ENGINEERING)
REFINERY ENGINEERING CALCULATIONS
PKC3070
Credits: 04

Maximum Marks: 60 **Duration: Two Hours.**

Answer all the questions.
Notations used have their usual meaning

Q No 1 **All question has equal marks** **3.0x4 = 12.0**

(a) List down the top three countries in terms of reserve, production and consumption of crude oil in 2020? CO1

OR

(a') Why intermediate refluxes are required in the atmospheric distillation column, and how can it be achieved? CO1

(b) Compare the R and A type refluxes used in atmospheric distillation column. CO1

(c) Discuss the different mode of residue operations in the vacuum distillation column. CO1

OR

(c') Why vacuum distillation column is required in refinery operation? Also explain the differences between the overflash of the atmospheric and vacuum distillation column? CO1

(d) Why extended surface is needed in convection section? Which type of extended surface is better. CO3

Q No 2 **All question has equal marks** **5.0x4 = 20.0**

(a) What do you mean by refinery configuration? Discuss the coking refinery configuration with the help of a neat sketch of the refinery layout and its products. CO1

(b) What is the significance of flash zone in the atmospheric distillation column, and why is the bottom steam required in the atmospheric distillation column? CO2

Contd ...2o

OR

(b') What are the process variables required for material balance of the atmospheric distillation column? Explain how to fix temperature and pressure at the flash zone in atmospheric distillation column. CO2

(c) Discuss the economic considerations required in the designing of the vacuum distillation tower. CO2

(d) What do you mean by the term "draft" in refinery furnaces? Discuss the forced draft used in furnaces with the help of neat diagram. CO3,

OR

(d') Discuss any two of the following components of the refinery furnaces CO3

a) Soot blowers
b) Burners
c) Tubes/pipes

Q No 3 **All question has equal marks** **7.0x4 = 28.0**

(a) Compare the IBP and FBP of TBP, ASTM & EFV distillation curve with the help of neat sketch. Also, find out the following parameters of the given TBP curve for the cut range of 30-70 volume %. The TBP equation used for the calculation is given below as; CO2

$Y = 0.0012X^3 - 0.1633X^2 + 9.9376X + 60.698$ ----------(Eq. 1)

where, X= volume % distilled, Y= Temperature, °C

1) TBP & ASTM slope
2) TBP & ASTM T50%
3) TBP & ASTM IBP
4) TBP & ASTM FBP

$y = 0.0028x^4 - 0.0555x^3 + 0.3311x^2 + 0.2677x + 0.0168$ ----------(Eq. 2)

where, X= TBP slope, Y= ASTM slope

$y = 1.05x$ ----------(Eq. 3)

where, X= TBP $T_{50\%}$, Y= ASTM $T_{50\%}$

$y = 0.9247x + 70.754$ ----------(Eq. 4)

where, X= TBP IBP, Y= ASTM IBP

$y = 0.941x + 6.3789$ ----------(Eq. 5)

where, X= TBP FBP, Y= ASTM FBP

OR

Contd.... 3.

(a') If a binary system is used for TBP & ASTM distillation analysis, how would be its distillation curve? Further, calculate the TBP temperature of the given oil sample for which ASTM D86 temperature w.r.t volume % distilled are given along with conversion coefficient a and b. CO2

Volume % Distilled	Coefficient, a	Coefficient, b	Temperature ASTM D86, °C
0	0.9177	1.0019	36.5
10	0.5564	1.0900	54.0
30	0.7617	1.0425	77.0
50	0.9013	1.0176	101.5
70	0.8821	1.0226	131.0
90	0.9552	1.0110	171.0
95	0.8177	1.0355	186.5

(b) Find out the distillate yield for LN and HN (in vol% of feed) of the atmospheric distillation column with the help of the following parameters. CO2

Stream	ASTM EP, °F	Gap	ASTM (5-95) Gap, °F
LN	280	LN-HN	+25
HN	380	HN-LD	+35

TBP to ASTM End Point

$y = 0.941x + 6.3789$ ..... **(Eq. 6)**

y = ASTM Endpoint (EP), °F, x = TBP Endpoint (EP), °F

For LN-HN & HN-LD

$y = -0.013x^2 - 1.334x + 134$ .....**(Eq. 7)**

y = TBP overlap, x = ASTM Gap

TBP curve equation

$y = -6E\text{-}08x^3 + 1E\text{-}04x^2 + 0.0448x - 2.8916$..... **(Eq. 8)**

y = TBP vol %, x = temperature, °F

(c) It is planned to operate vacuum tower in lube asphalt mode as well as fuel pitch mode. Find out the products range in both mode of operation for the given conditions. CO4

- Vacuum feed range = 52-100 vol % of crude oil

For lube asphalt mode

- Penetration Index of Asphalt@77 °F 70
- Heavy Lube Cut Viscosity @100 °F, SSU 700
- Heavy Lube Cut Yield @ Whole Crude Basis, Vol% 6
- Light Lube Cut Viscosity @100 °F, SSU 150
- Light Lube Cut Yield @ Whole Crude Basis, Vol% 4

Viscosity equation @ 100 °F,

$y=10.6052 \ln(x)+3.3122$ ----------(Eq. 9)

where, x = viscosity in SSU and y= mid vol % on whole crude

Asphalt Yield, Vol % on Whole Crude,

$y = -0.00014x^2 + 0.06454x + 19.45661$ --------(Eq. 10)

Where, x= penetration index and y = asphalt yield

For fuel pitch mode,

Contd ....4.

- TBP cût point between the distillates and the residuum is 1100 °F
- LVGO is 30 % of VGO

TBP equation = y = 12.958x + 27.533 ----------(Eq. 11)

Where, y = Whole TBP temperature, °F, x = Vol %

(c') It is planned to yield two VGO cuts (LVGO & HVGO) from the bottom of atmospheric tower in the vacuum tower which is operated as fuel pitch mode. Carry out the material balance (moles/hr) of each stream recovered from vacuum tower for the following conditions. CO4

Feedstock = 49000 BPSD @ 17.4 °API & range = 51.0 - 100 vol % of whole crude,
Over flash = 2.0 vol% of vacuum feed treated as separate product,
TBP cut point between VGO & vacuum residue = 1050 °F,
LVGO = 35% VGO

TBP curve formula:

$Y = -3.58347*10^{-12}\ X^5 + 1.76443*10^{-8}\ X^4 - 3.4327*10^{-5}\ X^3 + 0.032866256\ X^2 - 15.2926*X + 2750.118$ ----------(Eq. 12)

Where X = Temperature, °F %, Y = Volume %

API formula:

$y = 6.425E\text{-}09x^6 - 1.831E\text{-}06x^5 + 2.061E\text{-}04x^4 - 1.167E\text{-}02x^3 + 3.535E\text{-}01x^2 - 6.164x + 97$ ---------- **Eq. 13)**

where, y = API, x = mid vol %
Assume API for pitch (residue) = 6.6

Mol Wt. = $0.005\ X^3 - 0.2\ V^2 + 5.4\ V + 68$ ----------(Eq. 14)

Where V= mid volume % of vapor

(d) A petroleum stock at a rate of 2000 bbl/hr of API 56.2 is allowed to enter directly the radiant section of box type heater at 250 °C. The heater is designed to burn 4500 kgs per hour of refinery off gases as fuel. The net heating value of fuel is 49500 KJ/kg. The radiant section contains 195 sq. meters of projected area of one row of tubes (10.5 cm OD, 12 m long and spaced at 2 OD). Find the outlet temperature of the petroleum stock. CO3

Data given as

$\alpha = 0.88$, Air fuel ratio= 25, Average sp. heat of stock= 2.368 KJ/Kg øC