GATE Chemical Engineering

Sample Paper – 4

Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Chemical Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Take $R = 8.314$ J/mol·K and $g = 9.81$ m/s^2 unless stated otherwise.

Process Calculations & Thermodynamics

Q1. A gas mixture is prepared from 4 mol of nitrogen and 1 mol of oxygen. The mole fraction of oxygen in the mixture is: **[1 mark]**

(A) 0.20

(B) 0.25

(C) 0.80

(D) 0.50

Q2. Methane burns completely in oxygen following $\mathrm{CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O}$. The mass of oxygen (molar mass 32) required to burn 8 kg of methane (molar mass 16) completely is: **[1 mark]**

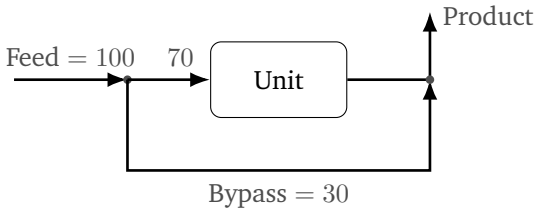
(A) 32 kg

(B) 16 kg

(C) 64 kg

(D) 8 kg

Q3. In the steady operation sketched below, a feed of 100 mol/h reaches a splitter where part of the stream bypasses the process unit. If the bypass stream is 30 mol/h, the fraction of the feed that actually passes through the unit is: **[1 mark]**



(A) 0.30

(B) 0.70

(C) 0.35

(D) 1.0

Q4. A gas contained in a piston–cylinder is compressed adiabatically, and the surroundings perform 150 J of work on the gas. Since the process is adiabatic, $Q = 0$. By the first law for a closed system, the change in internal energy of the gas is: **[1 mark]**

(A) $+150$ J

(B) -150 J

(C) 0 J

(D) $+300$ J

Q5. One mole of an ideal gas expands isothermally and reversibly at 300 K from a volume V to a volume $2V$. Taking $R = 8.314$ J/mol·K, the entropy change of the gas ($\Delta S = R \ln 2$) is nearest to: **[1 mark]**

(A) 8.31 J/K

(B) 2.88 J/K

(C) 11.5 J/K

(D) 5.76 J/K

Q6. Carbon dioxide (molar mass 44 g/mol) behaves as an ideal gas at a temperature of 300 K and a pressure of 1 bar (10^5 Pa). Taking $R = 8.314$ J/mol·K, the mass density of the gas ($\rho = PM/RT$) is nearest to: **[1 mark]**

(A) 0.44 kg/m^3

(B) 44 kg/m^3

(C) 0.88 kg/m^3

(D) 1.76 kg/m^3

Q7. A gas-phase reaction has a thermodynamic equilibrium constant $K = 10$ at 300 K. Using $\Delta G^\circ = -RT \ln K$ with $R = 8.314$ J/mol·K, the standard Gibbs free energy change of the reaction is nearest to: **[1 mark]**

(A) -5.74 kJ/mol

(B) $+5.74$ kJ/mol

(C) -2.49 kJ/mol

(D) 0 kJ/mol

Q8. A benzene (A)–toluene (B) mixture behaves ideally and obeys Raoult's law. At the system temperature $P_A^{sat} = 120$ kPa and $P_B^{sat} = 80$ kPa. For a liquid of composition $x_A = 0.4$, the mole fraction of A in the vapour, $y_A = x_A P_A^{sat}/P$, is: **[1 mark]**

(A) 0.40

(B) 0.60

(C) 0.50

(D) 0.96

Q9. A real gas at 300 K and a pressure of 1.2×10^5 Pa is found to have a molar volume of 0.020 m^3/mol. Taking $R = 8.314$ J/mol·K, the compressibility factor of the gas ($Z = PV/RT$) is nearest to: **[1 mark]**

(A) 1.0

(B) 1.2

(C) 0.50

(D) 0.96

Q10. A reversible Carnot refrigerator maintains a cold space at 250 K while rejecting heat to surroundings at 300 K. The coefficient of performance of the refrigerator (COP $= T_C/(T_H - T_C)$) is: **[1 mark]**

(A) 6.0

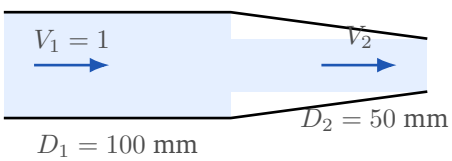
(B) 5.0

(C) 0.83

(D) 1.2

Fluid Mechanics & Mechanical Operations

Q11. Water flows steadily through the horizontal pipe contraction shown. The pipe diameter reduces from 100 mm to 50 mm and the mean velocity at the inlet is 1 m/s. By the continuity equation $A_1V_1 = A_2V_2$, the mean velocity at the outlet is: **[1 mark]**



(A) 1 m/s

(B) 2 m/s

(C) 0.5 m/s

(D) 4 m/s

Q12. Water of density 1000 kg/m^3 and dynamic viscosity 1×10^{-3} Pa·s flows through a pipe of diameter 100 mm at a mean velocity of 0.05 m/s. The Reynolds number of the flow ($Re = \rho V D/\mu$) is: **[1 mark]**

(A) 5000

(B) 500

(C) 50000

(D) 2500

Q13. Water flows through a horizontal pipe of length 100 m and diameter 0.1 m at a mean velocity of 2 m/s. The Darcy friction factor is $f = 0.02$. Using the Darcy–Weisbach equation $h_f = f\,\dfrac{L}{D}\,\dfrac{V^2}{2g}$, the head loss due to friction is nearest to: **[1 mark]**

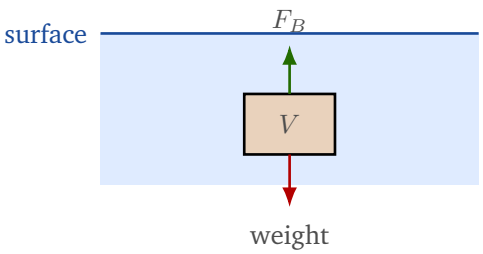
(A) 2.04 m

(B) 4.08 m

(C) 8.15 m

(D) 1.0 m

Q14. A solid body of volume 1×10^{-3} m^3 is fully submerged in water of density 1000 kg/m^3, as shown. Taking $g = 9.81$ m/s^2, the buoyant (upthrust) force on the body, $F_B = \rho_w\, g\, V$, is: **[1 mark]**



(A) 1.0 N

(B) 100 N

(C) 9.81 N

(D) 0.98 N

Q15. At a point in a process line the gauge pressure of a fluid is measured as 50 kPa. If the local atmospheric pressure is 101.3 kPa, the absolute pressure at that point (absolute $=$ gauge $+$ atmospheric) is: **[1 mark]**

(A) 50 kPa

(B) 51.3 kPa

(C) 101.3 kPa

(D) 151.3 kPa

Q16. In particle technology the specific surface area of a particle is its surface area divided by its volume. For a spherical particle this equals $6/d$, where d is the diameter. For a sphere of diameter 2 mm, the specific surface area is: **[1 mark]**

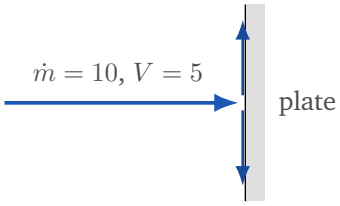
(A) 1500 m^2/m^3

(B) 3000 m^2/m^3

(C) 6000 m^2/m^3

(D) 300 m^2/m^3

Q17. A horizontal water jet of mass flow rate 10 kg/s and velocity 5 m/s strikes a large stationary flat plate normally, as shown, and the water spreads sideways. The force exerted by the jet on the plate ($F = \dot{m}\,V$) is: **[1 mark]**



(A) 50 N

(B) 100 N

(C) 25 N

(D) 250 N

Q18. Which size-reduction law states that the energy required per unit mass of feed is proportional to the size-reduction ratio (the ratio of feed size to product size), and is therefore best suited to coarse crushing? [1 mark]

(A) Rittinger's law

(B) Bond's law

(C) Kick's law

(D) Fick's law

Q19. A jaw crusher reduces a feed of average size 50 mm to a product of average size 10 mm. The size-reduction ratio (feed size divided by product size) is: [1 mark]

(A) 5

(B) 0.2

(C) 10

(D) 40

Q20. Steady one-dimensional conduction occurs through a plane wall of thermal conductivity 0.5 W/m·K, cross-sectional area 2 m^2 and thickness 0.1 m. The thermal (conduction) resistance of the wall, $R = L/(kA)$, is: [1 mark]

(A) 0.4 K/W

(B) 0.2 K/W

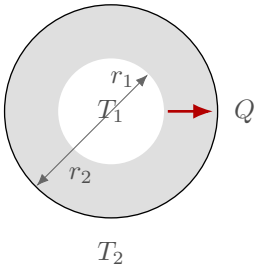
(C) 0.05 K/W

(D) 0.1 K/W

Heat Transfer

Q21. Steady radial heat conduction occurs through the wall of the long cylindrical pipe shown. The metal has conductivity $k = 50$ W/m·K, the length is $L = 1$ m, the inner radius is $r_1 = 10$ mm and the outer radius is $r_2 = 20$

mm, and the inner and outer surfaces differ in temperature by 100 K. Using $Q = \dfrac{2\pi k L\,(T_1 - T_2)}{\ln(r_2/r_1)}$, the heat conduction rate is nearest to: **[2 marks]**



(A) 45.3 kW

(B) 22.7 kW

(C) 90.6 kW

(D) 31.4 kW

Q22. A metal block is quenched in a fluid. The block has a characteristic length $L_c = 0.01$ m and thermal conductivity $k = 200$ W/m·K, and the surface convective coefficient is $h = 100$ W/m^2·K. The Biot number (Bi $= hL_c/k$) of the block is: **[2 marks]**

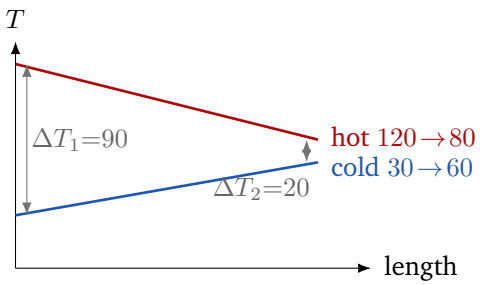
(A) 0.02

(B) 0.5

(C) 0.05

(D) 0.005

Q23. In the parallel-flow double-pipe exchanger whose temperature profile is sketched, a hot fluid is cooled from 120 °C to 80 °C while a cold fluid is heated from 30 °C to 60 °C. The logarithmic mean temperature difference (LMTD) for the exchanger is nearest to: **[2 marks]**



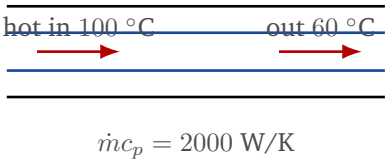
(A) $55.0\ ^\circ$C

(B) $46.5\ ^\circ$C

(C) $40.0\ ^\circ$C

(D) $90.0\ ^\circ$C

Q24. In the double-pipe exchanger shown, a hot stream with heat-capacity rate $\dot{m}c_p = 2000$ W/K is cooled from $100\ ^\circ$C to $60\ ^\circ$C. Using the energy balance $Q = \dot{m}c_p\,\Delta T$, the heat duty of the exchanger is: **[2 marks]**



(A) 40 kW

(B) 120 kW

(C) 80 kW

(D) 20 kW

Q25. Heat is transferred from a hot fluid to a cold fluid across a wall whose own resistance is negligible. The two convective film coefficients are $h_1 = 200$ W/m^2·K and $h_2 = 300$ W/m^2·K. Using $\dfrac{1}{U} = \dfrac{1}{h_1} + \dfrac{1}{h_2}$, the overall heat-transfer coefficient U is nearest to: **[2 marks]**

(A) 250 W/m^2·K

(B) 500 W/m^2·K

(C) 120 W/m^2·K

(D) 100 W/m^2·K

Q26. A gray surface with an emissivity of 0.8 is held at a temperature of 400 K. Taking the Stefan–Boltzmann constant as $\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4, the total emissive power of the surface ($E = \varepsilon\,\sigma\,T^4$) is nearest to: **[2 marks]**

(A) 1452 W/m^2

(B) 1161 W/m^2

(C) 726 W/m^2

(D) 2322 W/m^2

Q27. A single-effect evaporator is heated by saturated steam whose latent heat of condensation is 2200 kJ/kg. The steam is supplied at a rate of 0.5 kg/s. Assuming all the latent heat is transferred to the boiling liquor, the heat duty of the evaporator ($Q = \dot{m}_{\text{steam}}\,\lambda$) is: **[2 marks]**

(A) 2200 kW

(B) 1100 kW

(C) 550 kW

(D) 4400 kW

Mass Transfer & Separation Processes

Q28. A solute diffuses through a liquid of density 1000 kg/m^3 and dynamic viscosity 1×10^{-3} Pa·s. Its molecular diffusivity in the liquid is $D_{AB} = 1 \times 10^{-9}$ m^2/s. The Schmidt number of the system ($\text{Sc} = \mu/(\rho D_{AB})$) is: **[2 marks]**

(A) 100

(B) 500

(C) 1000

(D) 2000

Q29. In a mass-transfer correlation the film mass-transfer coefficient is $k_c = 0.02$ m/s, the characteristic length is $L = 0.1$ m and the molecular diffusivity is $D = 2 \times 10^{-5}$ m^2/s. The Sherwood number ($\text{Sh} = k_c L/D$) is: **[2 marks]**

(A) 100

(B) 200

(C) 50

(D) 1000

Q30. According to penetration theory, the liquid-phase mass-transfer coefficient is $k_c = 2\sqrt{\dfrac{D}{\pi\, t_c}}$. For a diffusivity $D = 1 \times 10^{-9}$ m^2/s and a contact (exposure) time $t_c = 1$ s, the mass-transfer coefficient is nearest to: **[2 marks]**

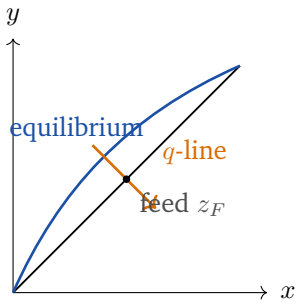
(A) 1.78×10^{-5} m/s

(B) 3.57×10^{-5} m/s

(C) 7.14×10^{-5} m/s

(D) 5.05×10^{-5} m/s

Q31. The McCabe–Thiele construction below shows the feed (q) line for a distillation column. For a feed that enters 50 mol% vaporized, $q = 0.5$. The slope of the q-line, equal to $q/(q-1)$, is: **[2 marks]**



(A) -0.5

(B) -1.0

(C) $+1.0$

(D) $+0.5$

Q32. A distillation column is operated at a reflux ratio equal to 1.5 times the minimum reflux ratio. If the minimum reflux ratio for the separation is $R_{\min} = 2.0$, the operating reflux ratio ($R = 1.5\, R_{\min}$) is: **[2 marks]**

(A) 3.0

(B) 2.0

(C) 1.5

(D) 5.0

Q33. In a stripping column the liquid flow rate is $L = 100$ mol/h, the gas flow rate is $G = 50$ mol/h and the equilibrium slope is $m = 2.0$. The stripping factor, defined as $S = mG/L$, is: **[2 marks]**

(A) 0.5

(B) 1.0

(C) 2.0

(D) 4.0

Q34. A packed distillation column has a total packed height of 4 m and is found to accomplish 8 theoretical stages of separation. The height equivalent to a theoretical plate (HETP = packed height / number of theoretical stages) is: **[2 marks]**

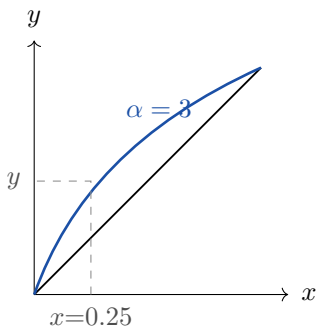
(A) 2.0 m

(B) 1.0 m

(C) 0.5 m

(D) 32 m

Q35. The vapour–liquid equilibrium curve of a binary mixture with constant relative volatility $\alpha = 3$ is sketched below. Using the equilibrium relation $y = \dfrac{\alpha x}{1 + (\alpha - 1)x}$, the vapour mole fraction in equilibrium with a liquid of composition $x = 0.25$ is: **[2 marks]**



(A) 0.25

(B) 0.75

(C) 0.375

(D) 0.50

Q36. A wet solid held in a dryer contains a total moisture of 0.40 kg water per kg dry solid. Under the prevailing air conditions the equilibrium moisture content of the solid is 0.05 kg water per kg dry solid. The free moisture content (total moisture minus equilibrium moisture) available for drying is: **[2 marks]**

(A) 0.45 kg/kg

(B) 0.40 kg/kg

(C) 0.35 kg/kg

(D) 0.05 kg/kg

Reaction Engineering, Process Control & Plant Economics

Q37. A liquid-phase reaction is second order in the reactant, with a rate constant $k = 0.5$ L/mol·min. The initial reactant concentration is $C_{A0} = 2$ mol/L. The half-life of the reactant, $t_{1/2} = \dfrac{1}{k\,C_{A0}}$, is: **[2 marks]**

(A) 0.5 min

(B) 2.0 min

(C) 4.0 min

(D) 1.0 min

Q38. An ideal continuous stirred-tank reactor is fed by a liquid stream at a constant volumetric flow rate of 10 L/min. The required space time for the desired conversion is $\tau = 5$ min. Using $V = Q\,\tau$, the working volume of the reactor is: **[2 marks]**

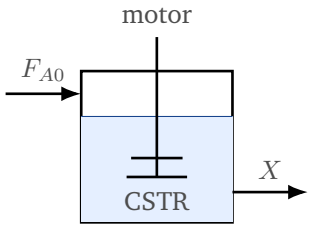
(A) 2 L

(B) 100 L

(C) 50 L

(D) 20 L

Q39. A first-order liquid-phase reaction ($-r_A = kC_A$, $k = 0.2$ min^{-1}) is carried out in the ideal CSTR shown with a space time of $\tau = 5$ min. Using the CSTR relation $X = \dfrac{k\tau}{1 + k\tau}$, the fractional conversion at the reactor outlet is: **[2 marks]**



(A) 0.500

(B) 0.667

(C) 0.333

(D) 0.800

Q40. A homogeneous liquid-phase reaction is second order in the reactant A, with rate law $-r_A = k\,C_A^2$. The rate constant is $k = 2$ L/mol·min and the reactant concentration at a given instant is $C_A = 3$ mol/L. The reaction rate at that instant is: **[2 marks]**

(A) 6 mol/L·min

(B) 9 mol/L·min

(C) 12 mol/L·min

(D) 18 mol/L·min

Q41. An ideal reactor of working volume 50 L is fed by a liquid stream at a constant volumetric flow rate of 25 L/min. The space velocity of the reactor (defined as the volumetric feed rate divided by the reactor volume, Q/V) is: **[2 marks]**

(A) 2.0 min^{-1}

(B) 0.5 min^{-1}

(C) $1.0\ \text{min}^{-1}$

(D) $0.25\ \text{min}^{-1}$

Q42. Reactant A decomposes by two parallel first-order reactions: a desired path $A \rightarrow R$ with rate constant $k_1 = 2\ \text{min}^{-1}$ and an undesired path $A \rightarrow S$ with rate constant $k_2 = 6\ \text{min}^{-1}$. The instantaneous fractional yield of R, given by $k_1/(k_1 + k_2)$, is: **[2 marks]**

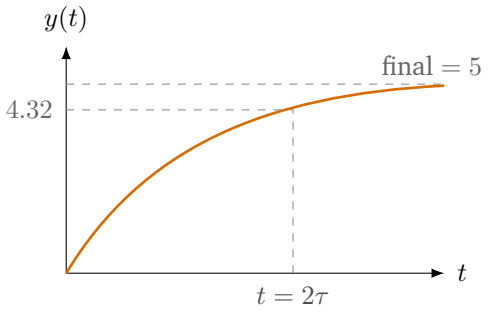
(A) 0.50

(B) 0.25

(C) 0.75

(D) 0.33

Q43. A first-order process with steady-state gain $K = 5$ and time constant $\tau = 10$ min is subjected to a unit step change in its input. Its response follows $y(t) = K\,(1 - e^{-t/\tau})$, as sketched. The value of the output at $t = 2\tau$ (two time constants) is nearest to: **[2 marks]**



(A) 5.0

(B) 3.16

(C) 4.32

(D) 2.5

Q44. A process with steady-state gain K_p is controlled by a proportional controller of gain K_c, and the product $K_c K_p = 3$. For a unit step change in the set point the residual steady-state offset of a pure proportional loop is $1/(1 + K_c K_p)$. The offset is: **[2 marks]**

(A) 1.0

(B) 0.75

(C) 0.25

(D) 0.50

Q45. A first-order process is described by the transfer function $G(s) = \dfrac{5}{2s+1}$. The pole of this transfer function (the value of s that makes the denominator zero) is located at: [2 marks]

(A) $s = -2$

(B) $s = +0.5$

(C) $s = -1$

(D) $s = -0.5$

Q46. A process plant requires a capital investment of Rs. $10{,}00{,}000$ and is expected to generate a constant net annual cash profit of Rs. $2{,}50{,}000$. The simple payback period (capital investment divided by annual cash profit) is: [2 marks]

(A) 4 years

(B) 2.5 years

(C) 5 years

(D) 40 years

Detailed Solutions

Q1.

Solution

Concept – mole fraction is the moles of a component divided by the total moles of the mixture: $y_{O_2} = \dfrac{\text{moles of } O_2}{\text{moles of } N_2 + \text{moles of } O_2}$.

Step 1 – list the moles: Moles of $N_2 = 4$, moles of $O_2 = 1$.

Step 2 – find the total moles: $n_{\text{total}} = 4 + 1$

$n_{\text{total}} = 5$ mol

Step 3 – form the mole fraction of oxygen: $y_{O_2} = \dfrac{1}{5}$

Step 4 – evaluate: $y_{O_2} = 0.20$

Final Answer: $y_{O_2} = 0.20 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept – use the stoichiometry of the combustion reaction: $CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$, so 1 mole of methane needs 2 moles of oxygen.

Step 1 – find the moles of methane burnt: $n_{CH_4} = \dfrac{8 \text{ kg}}{16 \text{ kg/kmol}} = 0.5$ kmol

Step 2 – apply the $1:2$ mole ratio: $n_{O_2} = 2 \times n_{CH_4} = 2 \times 0.5 = 1$ kmol

Step 3 – convert oxygen moles to mass: $m_{O_2} = n_{O_2} \times M_{O_2} = 1 \times 32$

$m_{O_2} = 32$ kg

Final Answer: $m_{O_2} = 32 \text{ kg} \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q2

Q3.

Solution

Concept – a total mass (mole) balance at the splitter: The feed splits into the bypass stream and the stream that enters the unit, so the processed stream = feed − bypass.

Step 1 – read the streams from the diagram: Feed = 100 mol/h, bypass = 30 mol/h.

Step 2 – find the stream through the unit: $F_{\text{unit}} = 100 - 30 = 70$ mol/h

Step 3 – form the required fraction: $\text{fraction} = \dfrac{F_{\text{unit}}}{\text{feed}} = \dfrac{70}{100}$

Step 4 – evaluate: $\text{fraction} = 0.70$

Final Answer: fraction through unit $= 0.70 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept – first law for a closed system: $\Delta U = Q - W$, with Q the heat added to the system and W the work done *by* the system.

Step 1 – assign signs to the two energy terms: The process is adiabatic, so $Q = 0$. Work is done *on* the gas, so the work done *by* the gas is $W = -150$ J.

Step 2 – substitute into the first law: $\Delta U = 0 - (-150)$

Step 3 – evaluate: $\Delta U = +150$ J

Why the sign matters: Compression work done on the gas raises its internal energy, so ΔU must be positive.

Final Answer: $\Delta U = +150$ J $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – entropy change for the isothermal reversible expansion of an ideal gas: $\Delta S = nR \ln \dfrac{V_2}{V_1}$.

Step 1 – list the data: $n = 1$ mol, $R = 8.314$ J/mol·K, $V_2/V_1 = 2$.

Step 2 – take the logarithm of the volume ratio: $\ln 2 = 0.6931$

Step 3 – substitute: $\Delta S = 1 \times 8.314 \times 0.6931$

Step 4 – multiply: $\Delta S = 5.763$ J/K

Step 5 – round: $\Delta S \approx 5.76$ J/K

Final Answer: $\Delta S \approx 5.76$ J/K $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – ideal-gas density from the ideal-gas law: $PV = nRT$ gives $\rho = \dfrac{PM}{RT}$, where M is the molar mass.

Step 1 – list the data in SI units: $P = 10^5$ Pa, $M = 44$ g/mol $= 0.044$ kg/mol, $R = 8.314$ J/mol·K, $T = 300$ K.

Step 2 – compute the numerator: $PM = 10^5 \times 0.044 = 4400$

Step 3 – compute the denominator: $RT = 8.314 \times 300 = 2494.2$

Step 4 – divide: $\rho = \dfrac{4400}{2494.2}$

Step 5 – evaluate: $\rho = 1.764$ kg/m$^3 \approx 1.76$ kg/m^3

Final Answer: $\rho \approx 1.76$ kg/m$^3 \Rightarrow$ D

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – relation between standard Gibbs energy and the equilibrium constant: $\Delta G^\circ = -RT \ln K$.

Step 1 – list the data: $R = 8.314$ J/mol·K, $T = 300$ K, $K = 10$.

Step 2 – take the logarithm of K: $\ln 10 = 2.3026$

Step 3 – form the product RT: $RT = 8.314 \times 300 = 2494.2$ J/mol

Step 4 – substitute into the relation: $\Delta G^\circ = -\,2494.2 \times 2.3026$

Step 5 – multiply: $\Delta G^\circ = -5743$ J/mol

Step 6 – express in kilojoules: $\Delta G^\circ \approx -5.74$ kJ/mol

Final Answer: $\Delta G^\circ \approx -5.74$ kJ/mol $\Rightarrow$ A

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – vapour composition from Raoult's law and Dalton's law: $y_A = \dfrac{x_A P_A^{sat}}{P}$, where $P = x_A P_A^{sat} + x_B P_B^{sat}$ is the total pressure.

Step 1 – list the data: $P_A^{sat} = 120$ kPa, $P_B^{sat} = 80$ kPa, $x_A = 0.4$, so $x_B = 0.6$.

Step 2 – find the total pressure: $P = (0.4)(120) + (0.6)(80)$

Step 3 – evaluate each term: $P = 48 + 48 = 96$ kPa

Step 4 – form the partial pressure of A: $x_A P_A^{sat} = 0.4 \times 120 = 48$ kPa

Step 5 – divide to get the vapour mole fraction: $y_A = \dfrac{48}{96} = 0.5$

Final Answer: $y_A = 0.5 \Rightarrow$ C

Answer: (C) Go Back to Q8

Q9.

Solution

Concept – compressibility factor measures departure from ideal-gas behaviour: $Z = \dfrac{PV}{RT}$, using the molar volume V.

Step 1 – list the data in SI units: $P = 1.2 \times 10^5$ Pa, $V = 0.020$ m^3/mol, $R = 8.314$ J/mol·K, $T = 300$ K.

Step 2 – compute the numerator: $PV = 1.2 \times 10^5 \times 0.020 = 2400$

Step 3 – compute the denominator: $RT = 8.314 \times 300 = 2494.2$

Step 4 – divide: $Z = \dfrac{2400}{2494.2}$

Step 5 – evaluate: $Z = 0.962 \approx 0.96$

Final Answer: $Z \approx 0.96 \Rightarrow$ D

Answer: (D) Go Back to Q9

Q10.

Solution

Concept – coefficient of performance of a Carnot refrigerator: $\text{COP} = \dfrac{T_C}{T_H - T_C}$, with temperatures in kelvin.

Step 1 – list the temperatures: $T_C = 250$ K, $T_H = 300$ K.

Step 2 – find the temperature difference: $T_H - T_C = 300 - 250 = 50$ K

Step 3 – substitute into the formula: $\text{COP} = \dfrac{250}{50}$

Step 4 – evaluate: $\text{COP} = 5.0$

Final Answer: $\text{COP} = 5.0 \Rightarrow$ B

Answer: (B) Go Back to Q10

Q11.

Solution

Concept – continuity for an incompressible fluid: $A_1V_1 = A_2V_2$, and since $A = \frac{\pi}{4}D^2$, this gives $V_2 = V_1\left(\frac{D_1}{D_2}\right)^2$.

Step 1 – list the data: $D_1 = 100$ mm, $D_2 = 50$ mm, $V_1 = 1$ m/s.

Step 2 – form the diameter ratio: $\frac{D_1}{D_2} = \frac{100}{50} = 2$

Step 3 – square the ratio: $\left(\frac{D_1}{D_2}\right)^2 = 2^2 = 4$

Step 4 – multiply by the inlet velocity: $V_2 = 1 \times 4 = 4$ m/s

Final Answer: $V_2 = 4$ m/s $\Rightarrow$ D

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – Reynolds number for pipe flow: $Re = \frac{\rho V D}{\mu}$.

Step 1 – list the data in SI units: $\rho = 1000$ kg/m^3, $V = 0.05$ m/s, $D = 0.1$ m, $\mu = 1 \times 10^{-3}$ Pa·s.

Step 2 – evaluate the numerator: $\rho V D = 1000 \times 0.05 \times 0.1$

$= 5$

Step 3 – divide by the viscosity: $Re = \frac{5}{1 \times 10^{-3}}$

Step 4 – evaluate: $Re = 5000$

Final Answer: $Re = 5000 \Rightarrow$ A

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – Darcy–Weisbach head loss in a pipe: $h_f = f\,\frac{L}{D}\,\frac{V^2}{2g}$.

Step 1 – list the data: $f = 0.02$, $L = 100$ m, $D = 0.1$ m, $V = 2$ m/s, $g = 9.81$ m/s^2.

Step 2 – form the length-to-diameter ratio: $\frac{L}{D} = \frac{100}{0.1} = 1000$

Step 3 – form the velocity-head term: $\dfrac{V^2}{2g} = \dfrac{2^2}{2 \times 9.81} = \dfrac{4}{19.62} = 0.2039$ m

Step 4 – multiply all the factors: $h_f = 0.02 \times 1000 \times 0.2039$

Step 5 – evaluate: $h_f = 20 \times 0.2039 = 4.077$ m ≈ 4.08 m

Final Answer: $h_f \approx 4.08$ m $\Rightarrow$ B

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – Archimedes' principle for a submerged body: The buoyant force equals the weight of displaced fluid, $F_B = \rho_w \, g \, V$.

Step 1 – list the data: $\rho_w = 1000$ kg/m^3, $g = 9.81$ m/s^2, $V = 1 \times 10^{-3}$ m^3.

Step 2 – multiply density and gravity: $\rho_w \, g = 1000 \times 9.81 = 9810$ N/m^3

Step 3 – multiply by the displaced volume: $F_B = 9810 \times 1 \times 10^{-3}$

Step 4 – evaluate: $F_B = 9.81$ N

Final Answer: $F_B = 9.81$ N $\Rightarrow$ C

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – relation between absolute, gauge and atmospheric pressure: $p_{\text{abs}} = p_{\text{gauge}} + p_{\text{atm}}$.

Step 1 – list the data: $p_{\text{gauge}} = 50$ kPa, $p_{\text{atm}} = 101.3$ kPa.

Step 2 – add the two pressures: $p_{\text{abs}} = 50 + 101.3$

Step 3 – evaluate: $p_{\text{abs}} = 151.3$ kPa

Final Answer: $p_{\text{abs}} = 151.3$ kPa $\Rightarrow$ D

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – specific surface area of a sphere: $a = \dfrac{\text{surface area}}{\text{volume}} = \dfrac{\pi d^2}{\frac{\pi}{6}d^3} = \dfrac{6}{d}$.

Step 1 – list the data in SI units: $d = 2$ mm $= 2 \times 10^{-3}$ m.

Step 2 – substitute into $a = 6/d$: $a = \dfrac{6}{2 \times 10^{-3}}$

Step 3 – evaluate: $a = 3000$ m^2/m^3

Final Answer: $a = 3000$ m^2/m$^3 \Rightarrow$ B

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – momentum (impulse) force of a jet on a plate: For a jet striking a stationary plate normally, all the axial momentum is destroyed, so $F = \dot{m}\,V$.

Step 1 – list the data: $\dot{m} = 10$ kg/s, $V = 5$ m/s.

Step 2 – substitute: $F = 10 \times 5$

Step 3 – evaluate: $F = 50$ N

Why option B (100 N) is wrong: $\dot{m}V$ (not $2\dot{m}V$) applies to a flat plate; the factor of two would apply only to a jet fully reversed by a hemispherical cup.

Final Answer: $F = 50$ N $\Rightarrow$ A

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – the three laws of size reduction: Kick's law takes the energy per unit mass as proportional to the logarithm of the size-reduction ratio, and is best for coarse crushing; Rittinger's law (new surface) suits fine grinding; Bond's law is intermediate.

Step 1 – identify the law tied to the size-reduction ratio and coarse crushing: This is Kick's law.

Step 2 – reject the others: Rittinger's law relates energy to new surface area (fine grinding); Fick's law is a diffusion law, not a size-reduction law.

Final Answer: Kick's law $\Rightarrow$ C

Answer: (C) Go Back to Q18

Q19.

Solution

Concept – size-reduction ratio: reduction ratio $= \dfrac{\text{feed size}}{\text{product size}}$.

Step 1 – list the data: Feed size $= 50$ mm, product size $= 10$ mm.

Step 2 – form the ratio: reduction ratio $= \dfrac{50}{10}$

Step 3 – evaluate: reduction ratio $= 5$

Final Answer: reduction ratio $= 5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – conduction (thermal) resistance of a plane wall: $R = \dfrac{L}{kA}$.

Step 1 – list the data: $L = 0.1$ m, $k = 0.5$ W/m·K, $A = 2$ m^2.

Step 2 – form the denominator: $kA = 0.5 \times 2 = 1.0$ W/K

Step 3 – divide the thickness by the denominator: $R = \dfrac{0.1}{1.0}$

Step 4 – evaluate: $R = 0.1$ K/W

Final Answer: $R = 0.1$ K/W $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – steady radial conduction through a cylindrical wall: $Q = \dfrac{2\pi k L\,(T_1 - T_2)}{\ln(r_2/r_1)}$.

Step 1 – list the data in SI units: $k = 50$ W/m·K, $L = 1$ m, $T_1 - T_2 = 100$ K, $r_1 = 0.010$ m, $r_2 = 0.020$ m.

Step 2 – form the radius ratio and its logarithm: $\dfrac{r_2}{r_1} = \dfrac{0.020}{0.010} = 2$, so $\ln 2 = 0.6931$

Step 3 – evaluate the numerator: $2\pi k L\,(T_1 - T_2) = 2\pi \times 50 \times 1 \times 100$

$= 31416$

Step 4 – divide by the logarithm: $Q = \dfrac{31416}{0.6931}$

Step 5 – evaluate: $Q = 45326$ W ≈ 45.3 kW

Final Answer: $Q \approx 45.3$ kW $\Rightarrow$ A

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – Biot number compares internal conduction with surface convection: $\text{Bi} = \dfrac{hL_c}{k}$.

Step 1 – list the data: $h = 100$ W/m^2·K, $L_c = 0.01$ m, $k = 200$ W/m·K.

Step 2 – form the numerator: $hL_c = 100 \times 0.01 = 1.0$

Step 3 – divide by the conductivity: $\text{Bi} = \dfrac{1.0}{200}$

Step 4 – evaluate: $\text{Bi} = 0.005$

Note: Since $\text{Bi} \ll 0.1$, lumped-capacitance analysis is valid for this block.

Final Answer: $\text{Bi} = 0.005 \Rightarrow$ D

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – logarithmic mean temperature difference: $\text{LMTD} = \dfrac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)}$, using the terminal temperature differences.

Step 1 – find the two terminal differences (parallel flow, so both ends compared at the same position): At the inlet end: $\Delta T_1 = 120 - 30 = 90$ °C.

At the outlet end: $\Delta T_2 = 80 - 60 = 20$ °C.

Step 2 – form the numerator: $\Delta T_1 - \Delta T_2 = 90 - 20 = 70$

Step 3 – form the logarithm of the ratio: $\ln\dfrac{90}{20} = \ln 4.5 = 1.5041$

Step 4 – divide: $\text{LMTD} = \dfrac{70}{1.5041}$

Step 5 – evaluate: LMTD $= 46.54$ °C ≈ 46.5 °C

Final Answer: LMTD ≈ 46.5 °C $\Rightarrow$ B

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – sensible-heat duty from an energy balance on one stream: $Q = \dot{m}c_p\,\Delta T$, using the heat-capacity rate $\dot{m}c_p$ and the temperature change.

Step 1 – list the data: $\dot{m}c_p = 2000$ W/K, hot inlet $= 100$ °C, hot outlet $= 60$ °C.

Step 2 – find the temperature drop: $\Delta T = 100 - 60 = 40$ K

Step 3 – substitute: $Q = 2000 \times 40$

Step 4 – evaluate: $Q = 80000$ W $= 80$ kW

Final Answer: $Q = 80$ kW $\Rightarrow$ C

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – overall heat-transfer coefficient for resistances in series: $\frac{1}{U} = \frac{1}{h_1} + \frac{1}{h_2}$ when the wall resistance is negligible.

Step 1 – list the data: $h_1 = 200$ W/m^2·K, $h_2 = 300$ W/m^2·K.

Step 2 – evaluate each reciprocal: $\frac{1}{h_1} = \frac{1}{200} = 0.005000$

$\frac{1}{h_2} = \frac{1}{300} = 0.003333$

Step 3 – add the reciprocals: $\frac{1}{U} = 0.005000 + 0.003333 = 0.008333$

Step 4 – invert to find U: $U = \frac{1}{0.008333}$

Step 5 – evaluate: $U = 120$ W/m^2·K

Final Answer: $U = 120$ W/m^2·K $\Rightarrow$ C

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – emissive power of a gray surface: $E = \varepsilon\,\sigma\,T^4$.

Step 1 – list the data: $\varepsilon = 0.8$, $\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4, $T = 400$ K.

Step 2 – raise the temperature to the fourth power: $T^4 = (400)^4 = 2.56 \times 10^{10}$ K^4

Step 3 – multiply by the Stefan–Boltzmann constant: $\sigma T^4 = 5.67 \times 10^{-8} \times 2.56 \times 10^{10}$

$= 1451.5$ W/m^2

Step 4 – multiply by the emissivity: $E = 0.8 \times 1451.5$

Step 5 – evaluate: $E = 1161.2$ W/m$^2 \approx 1161$ W/m^2

Final Answer: $E \approx 1161$ W/m$^2 \Rightarrow$ B

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – heat duty supplied by condensing steam: $Q = \dot{m}_{\text{steam}}\,\lambda$, the product of the steam mass flow and its latent heat.

Step 1 – list the data: $\dot{m}_{\text{steam}} = 0.5$ kg/s, $\lambda = 2200$ kJ/kg.

Step 2 – substitute: $Q = 0.5 \times 2200$

Step 3 – evaluate: $Q = 1100$ kJ/s $= 1100$ kW

Final Answer: $Q = 1100$ kW $\Rightarrow$ B

Answer: (B) Go Back to Q27

Q28.

Solution

Concept – Schmidt number compares momentum diffusivity with mass diffusivity: $\text{Sc} = \dfrac{\mu}{\rho D_{AB}}$.

Step 1 – list the data in SI units: $\mu = 1 \times 10^{-3}$ Pa·s, $\rho = 1000$ kg/m^3, $D_{AB} = 1 \times 10^{-9}$ m^2/s.

Step 2 – form the denominator: $\rho D_{AB} = 1000 \times 1 \times 10^{-9} = 1 \times 10^{-6}$

Step 3 – divide the viscosity by the denominator: $\text{Sc} = \dfrac{1 \times 10^{-3}}{1 \times 10^{-6}}$

Step 4 – evaluate: $\text{Sc} = 1000$

Final Answer: $\text{Sc} = 1000 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q28

Q29.

Solution

Concept – Sherwood number is the dimensionless mass-transfer coefficient: $\text{Sh} = \dfrac{k_c L}{D}$.

Step 1 – list the data in SI units: $k_c = 0.02$ m/s, $L = 0.1$ m, $D = 2 \times 10^{-5}$ m^2/s.

Step 2 – form the numerator: $k_c L = 0.02 \times 0.1 = 2 \times 10^{-3}$

Step 3 – divide by the diffusivity: $\text{Sh} = \dfrac{2 \times 10^{-3}}{2 \times 10^{-5}}$

Step 4 – evaluate: $\text{Sh} = 100$

Final Answer: $\text{Sh} = 100 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept – penetration-theory mass-transfer coefficient: $k_c = 2\sqrt{\dfrac{D}{\pi\, t_c}}$.

Step 1 – list the data: $D = 1 \times 10^{-9}$ m^2/s, $t_c = 1$ s.

Step 2 – form the ratio inside the root: $\dfrac{D}{\pi\, t_c} = \dfrac{1 \times 10^{-9}}{\pi \times 1} = \dfrac{1 \times 10^{-9}}{3.1416}$

$= 3.183 \times 10^{-10}$

Step 3 – take the square root: $\sqrt{3.183 \times 10^{-10}} = 1.784 \times 10^{-5}$

Step 4 – multiply by two: $k_c = 2 \times 1.784 \times 10^{-5}$

Step 5 – evaluate: $k_c = 3.568 \times 10^{-5}$ m/s $\approx 3.57 \times 10^{-5}$ m/s

Final Answer: $k_c \approx 3.57 \times 10^{-5}$ m/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – slope of the feed (q) line in the McCabe–Thiele method: slope $= \dfrac{q}{q-1}$, where q is the mole fraction of feed that is liquid.

Step 1 – find q for the given feed: The feed is 50 mol% vaporized, so the liquid fraction is $q = 0.5$.

Step 2 – form the denominator: $q - 1 = 0.5 - 1 = -0.5$

Step 3 – form the slope: slope $= \dfrac{0.5}{-0.5}$

Step 4 – evaluate: slope $= -1.0$

Final Answer: q-line slope $= -1.0 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q31

Q32.

Solution

Concept – operating reflux ratio as a multiple of the minimum: $R = (\text{factor}) \times R_{\min}$.

Step 1 – list the data: factor $= 1.5$, $R_{\min} = 2.0$.

Step 2 – substitute: $R = 1.5 \times 2.0$

Step 3 – evaluate: $R = 3.0$

Final Answer: $R = 3.0 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – stripping factor for a stripping column: $S = \dfrac{mG}{L}$, the inverse of the absorption factor.

Step 1 – list the data: $m = 2.0$, $G = 50$ mol/h, $L = 100$ mol/h.

Step 2 – form the numerator: $mG = 2.0 \times 50 = 100$

Step 3 – divide by the liquid rate: $S = \dfrac{100}{100}$

Step 4 – evaluate: $S = 1.0$

Final Answer: $S = 1.0 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q33

Q34.

Solution

Concept – height equivalent to a theoretical plate: $\text{HETP} = \dfrac{\text{packed height}}{\text{number of theoretical stages}}$.

Step 1 – list the data: Packed height $= 4$ m, number of theoretical stages $= 8$.

Step 2 – form the ratio: $\text{HETP} = \dfrac{4}{8}$

Step 3 – evaluate: $\text{HETP} = 0.5$ m

Final Answer: $\text{HETP} = 0.5$ m $\Rightarrow$ C

Answer: (C) Go Back to Q34

Q35.

Solution

Concept – equilibrium relation for constant relative volatility: $y = \dfrac{\alpha x}{1 + (\alpha - 1)x}$.

Step 1 – list the data: $\alpha = 3$, $x = 0.25$.

Step 2 – form the numerator: $\alpha x = 3 \times 0.25 = 0.75$

Step 3 – form the denominator: $1 + (\alpha - 1)x = 1 + (3 - 1)(0.25)$

$= 1 + 2 \times 0.25 = 1 + 0.5 = 1.5$

Step 4 – divide: $y = \dfrac{0.75}{1.5}$

Step 5 – evaluate: $y = 0.50$

Final Answer: $y = 0.50 \Rightarrow$ D

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – free moisture content is the moisture available for removal: $X_{\text{free}} = X_{\text{total}} - X^*$, where X^* is the equilibrium moisture content.

Step 1 – list the data: $X_{\text{total}} = 0.40$ kg/kg, $X^* = 0.05$ kg/kg.

Step 2 – subtract: $X_{\text{free}} = 0.40 - 0.05$

Step 3 – evaluate: $X_{\text{free}} = 0.35$ kg/kg

Final Answer: $X_{\text{free}} = 0.35$ kg/kg $\Rightarrow$ C

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – half-life of a second-order reaction: $t_{1/2} = \dfrac{1}{k\,C_{A0}}$.

Step 1 – list the data: $k = 0.5$ L/mol·min, $C_{A0} = 2$ mol/L.

Step 2 – form the product in the denominator: $k\,C_{A0} = 0.5 \times 2 = 1.0$ min^{-1}

Step 3 – take the reciprocal: $t_{1/2} = \dfrac{1}{1.0}$

Step 4 – evaluate: $t_{1/2} = 1.0$ min

Final Answer: $t_{1/2} = 1.0$ min $\Rightarrow$ D

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – space time relates reactor volume to the volumetric feed rate: $\tau = \dfrac{V}{Q}$, so $V = Q\,\tau$.

Step 1 – list the data: $Q = 10$ L/min, $\tau = 5$ min.

Step 2 – substitute into $V = Q\,\tau$: $V = 10 \times 5$

Step 3 – evaluate: $V = 50$ L

Final Answer: $V = 50$ L $\Rightarrow$ C

Answer: (C) Go Back to Q38

Q39.

Solution

Concept – conversion of a first-order reaction in an ideal CSTR: $X = \dfrac{k\tau}{1 + k\tau}$.

Step 1 – list the data: $k = 0.2$ min^{-1}, $\tau = 5$ min.

Step 2 – form the product $k\tau$: $k\tau = 0.2 \times 5 = 1.0$

Step 3 – substitute into the CSTR relation: $X = \dfrac{1.0}{1 + 1.0}$

Step 4 – evaluate the denominator: $X = \dfrac{1.0}{2.0}$

Step 5 – evaluate: $X = 0.500$

Note: For the same $k\tau = 1$ an ideal PFR would give $X = 1 - e^{-1} = 0.632$, which is higher than the CSTR value; a CSTR always needs a larger volume for the same first-order conversion.

Final Answer: $X = 0.500 \Rightarrow$ A

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – rate law for a second-order reaction: $-r_A = k\,C_A^2$.

Step 1 – list the data: $k = 2$ L/mol·min, $C_A = 3$ mol/L.

Step 2 – square the concentration: $C_A^2 = (3)^2 = 9$ mol^2/L^2

Step 3 – multiply by the rate constant: $-r_A = 2 \times 9$

Step 4 – evaluate: $-r_A = 18$ mol/L·min

Final Answer: $-r_A = 18$ mol/L·min $\Rightarrow$ D

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – space velocity is the reciprocal of the space time: $\text{SV} = \dfrac{Q}{V}$.

Step 1 – list the data: $Q = 25$ L/min, $V = 50$ L.

Step 2 – form the ratio: $\text{SV} = \dfrac{25}{50}$

Step 3 – evaluate: $\text{SV} = 0.5$ min^{-1}

Final Answer: $\text{SV} = 0.5$ min^{-1} $\Rightarrow$ B

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – instantaneous fractional yield for parallel first-order reactions: $\varphi_R = \dfrac{k_1}{k_1 + k_2}$, the fraction of A consumed that forms the desired product R.

Step 1 – list the data: $k_1 = 2$ min^{-1}, $k_2 = 6$ min^{-1}.

Step 2 – form the denominator: $k_1 + k_2 = 2 + 6 = 8$

Step 3 – form the ratio: $\varphi_R = \dfrac{2}{8}$

Step 4 – evaluate: $\varphi_R = 0.25$

Final Answer: $\varphi_R = 0.25 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q42

Q43.

Solution

Concept – step response of a first-order process: $y(t) = K\,(1 - e^{-t/\tau})$.

Step 1 – list the data: $K = 5$, $\tau = 10$ min, $t = 2\tau$.

Step 2 – form the exponent: $\dfrac{t}{\tau} = \dfrac{2\tau}{\tau} = 2$

Step 3 – evaluate the exponential: $e^{-2} = 0.1353$

Step 4 – form the bracket: $1 - e^{-2} = 1 - 0.1353 = 0.8647$

Step 5 – multiply by the gain: $y(2\tau) = 5 \times 0.8647$

Step 6 – evaluate: $y(2\tau) = 4.323 \approx 4.32$

Final Answer: $y(2\tau) \approx 4.32 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – residual offset of a pure proportional feedback loop: For a unit step set-point change, offset $= \dfrac{1}{1 + K_c K_p}$.

Step 1 – list the data: $K_c K_p = 3$.

Step 2 – form the denominator: $1 + K_c K_p = 1 + 3 = 4$

Step 3 – take the reciprocal: offset $= \dfrac{1}{4}$

Step 4 – evaluate: offset $= 0.25$

Note: A proportional-only controller always leaves a non-zero offset; adding integral action removes it.

Final Answer: offset $= 0.25 \Rightarrow$ C

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – pole of a first-order transfer function: For $G(s) = \dfrac{K}{\tau s + 1}$, the pole is the root of $\tau s + 1 = 0$, that is $s = -1/\tau$.

Step 1 – read the denominator: $G(s) = \dfrac{5}{2s + 1}$, so $\tau = 2$.

Step 2 – set the denominator to zero: $2s + 1 = 0$

Step 3 – solve for s: $2s = -1$

$s = -\dfrac{1}{2}$

Step 4 – evaluate: $s = -0.5$

Note: The pole lies in the left half of the s-plane, so the process is stable.

Final Answer: $s = -0.5 \Rightarrow$ D

Answer: (D) Go Back to Q45

Q46.

Solution

Concept – simple payback period: payback $= \dfrac{\text{capital investment}}{\text{annual cash profit}}$.

Step 1 – list the data: Capital investment $=$ Rs. $10{,}00{,}000$, annual cash profit $=$ Rs. $2{,}50{,}000$.

Step 2 – form the ratio: payback $= \dfrac{10{,}00{,}000}{2{,}50{,}000}$

Step 3 – evaluate: payback $= 4$ years

Final Answer: payback period $= 4$ years $\Rightarrow$ A

Answer: (A) Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	B	4	A	5	D
6	D	7	A	8	C	9	D	10	B
11	D	12	A	13	B	14	C	15	D
16	B	17	A	18	C	19	A	20	D
21	A	22	D	23	B	24	C	25	C
26	B	27	B	28	C	29	A	30	B
31	B	32	A	33	B	34	C	35	D
36	C	37	D	38	C	39	A	40	D
41	B	42	B	43	C	44	C	45	D
46	A								