CHEMICAL ENGINEERING

ONE MARKS QUESTIONS (1-20)

1. The ordinary differential equation dy/dt = f(Y) is solved using the approximation Y(t + Δt) = Y(t) + f[Y(t)] Δt. The numerical error introduced by the approximation at each step is
   a. proportional to Δt
   b. proportional to $(\Delta t)^2$
   c. independent of Δt
   d. proportional to (1/Δt)

2. The trapezoidal rule of integration when applied to $\int_a^b f(x)dx$ will give the exact value of the integral
   a. if f(x) is a linear function of x
   b. if f(x) is a quadratic function of x
   c. for any f(x)
   d. for no f(x)

3. The value of α for which the following three vectors are coplanar is
   a = i + 2j + k
   b = 3j + k
   c = 2i + αj
   a. 4
   b. zero
   c. –2
   d. –10

4. The derivative of |x| with respect to x when x≠0 is
   a. |x|/x
   b. –1
   c. 1
   d. Undefined

5. At a given temperature and pressure, a liquid mixture of benzene and toluene is in equilibrium with its vapor. The available degree(s) of freedom is (are)
   a. Zero
   b. 1
   c. 2
   d. 3

6. A heat engine operates at 75% of the maximum possible efficiency. The ratio of the heat source temperature (in K) to the heat sink temperature (in K) is 5/3. The fraction of the heat supplied that is
   a. 0.2
   b. 0.3
   c. 0.4
   d. 0.6

7. For the isentropic expansion of an ideal gas from the initial conditions P_1, T_1 to the final conditions P_2, T_2, which ONE of the following relations is valid? ($\gamma = C_p/C_v$)
   a. $\left(\frac{P_1}{P_2}\right) = \left(\frac{T_2}{T_1}\right)^{\gamma}$
   b. $\left(\frac{P_1}{P_2}\right) = \left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{\gamma-1}}$
   c. $\left(\frac{P_1}{P_2}\right) = \left(\frac{T_1}{T_2}\right)$
   d. $\left(\frac{P_1}{P_2}\right) = \left(\frac{T_1}{T_2}\right)^{\frac{\gamma-1}{\gamma}}$

8. Match the following for a centrifugal pump with impeller speed n
   List I
   A. Capacity
   B. Head
   List II
   1. proportional to n
   2. proportional to n^2
   3. proportional to n^3

	A	B
a.	2	1
b.	1	3
c.	2	3
d.	1	2

9. The magnitude of the force (in N) required to hold a body of volume 0.05 m^3 and mass 40kg in water (density 1000 kg/m^3) at a depth of 0.1 m is ($g = 9.81\ m/s^2$)
   a. Zero
   b. 98.1
   c. 490.5
   d. 882.9

10. A stagnant liquid film of 0.4 mm thickness is held between two parallel plates. The top plate is maintained at 40°C and the bottom plate is maintained at 30°C. If the thermal conductivity of the liquid is 0.14 W/(m K), then the steady state heat flux

a. 3.5
b. 350
c. 3500
d. 7000

11. Let d_h be the hydrodynamic entrance length for mercury in laminar flow in a pipe under isothermal conditions. Let d_t be its thermal entrance length under fully developed hydrodynamic conditions. Which ONE of the following is TRUE?
a. $d_h > d_t$
b. $d_h < d_t$
c. $d_h = d_t$
d. $d_h < d_t$ only if the pipe is vertical

12. The Boussinesq approximation for the fluid density in the gravitational force term is given by ONE of the following (ρ_{ref} is the fluid density at the reference temperature T_{ref}, and β is the thermal coefficient of volume expansion at T_{ref})
a. $\rho = \rho_{ref} + T_{ref}\beta(\rho - \rho_{ref})$
b. $\rho = \rho_{ref} - T_{ref}\beta(\rho - \rho_{ref})$
c. $\rho = \rho_{ref} - T_{ref}\beta(T - T_{ref})$
d. $\rho = \rho_{ref} - T_{ref}(\rho - \rho_{ref}) + \rho_{ref}(T - T_{ref})/T_{ref}$

13. The reaction 2A + B → 2C occurs on a catalyst surface. The reactants A and B diffuse to the catalyst surface and get converted completely to the product C which diffuses back. The steady state molar fluxes of A, B and C are related by
a. $N_A = 2N_B = -N_C$
b. $N_A = -(1/2) N_B = -N_C$
c. $NA = 2N_B - N_C$
d. $N_A = (1/2) N_B - N_C$

14. An ideal single stage extraction process is used to treat [illegible] molls of an organic feed solution. The solution concentration in this solution is to be reduced from 0.5 mol% to 0.1 mol%. A pure solvent S is used. To reduce the solvent requirement by half for the same separation,
a. add one more ideal co-current stage
b. use another pure solvent S* whose partition coefficient is twice that of S
c. use solvent S containing 0.02 mole fraction of the solute
d. double the residence time of the solvent S in the contactor

15. An irreversible gas phase reaction A → 5B is conducted in an isothermal batch reactor [illegible] volume of the gas at com[illegible] must not exceed three tim[illegible] volume, the minimum mole pe[illegible] inert in the feed must be
a. 0
b. 20
c. 33
d. 50

16. A first order reversible reaction

$$\rightleftharpoons$$

occurs in a batch reactor. The exponential decay of the concentration of A has the time constant
a. $\frac{1}{k_1}$
b. $\frac{1}{k_2}$
c. $\frac{1}{k_2 - k_1}$
d. $\frac{1}{k_1 + k_2}$

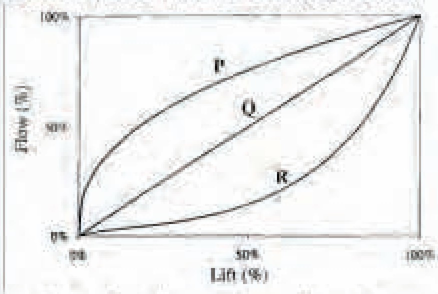
17. If the absolute error in the measurement of A is ΔA and the absolute error in the measurement of B is ΔB, then the absolute error in the estimate of A – B is
a. $\Delta A + \Delta B$
b. $\Delta A - \Delta B$
c. $\frac{\Delta A}{A} + \frac{\Delta B}{B}$
d. $\frac{\Delta A}{A} - \frac{\Delta B}{B}$

18. The oxo reaction is used for converting
a. alcohol to aldehyde
b. paraffin to olefin
c. olefin to aldehyde
d. aldehyde to alcohol

19. In a fluid catalytic cracking unit, the nature of the reactions occurring in the reactor and the regenerator is
a. Reactor-Exothermic, Regenerator-Exothermic
b. Reactor-Exothermic, Regenerator-Endothermic
c. Reactor-Endothermic, Regenerator-Exothermic
d. Reactor-Endothermic, Regenerator-Endothermic

20. The control valve characteristics for three

given in the figure below : Match the control valve with its characteristics.



a. P – Quick opening, Q – Linear, R – Equal percentage
b. P – Linear, Q – Square root, R – Equal percentage
c. P – Equal percentage, Q – Linear, R – Quick opening
d. P – Square root, Q – Quick opening, R – Linear

TWO MARKS QUESTIONS (21-75)

21. If the following represents the equation of a line

$$\begin{vmatrix} x & 2 & 4 \\ y & 8 & 0 \\ 1 & 1 & 1 \end{vmatrix} = 0$$

then the line passes through the point
a. (0, 0)
b. (3, 4)
c. (4, 3)
d. (4, 4)

22. If $A = \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}$, then the eigenvalues of A^3 are
a. 27 and 8
b. 64 and 1
c. 12 and 3
d. and

23. With ..., if the sum

$$S = \frac{dy}{dx} + \frac{d^2y}{dx^2} + \ldots + \frac{d^ny}{dx^n}$$

approaches 2y as $n \to \infty$, then the value of a is
a. 1/3
b. 1/2
c. 2/3
d. 2

24. Determine the following integral

$$I = \int r \, dS$$

where r is the position vector (ix + jy + kz) and S is the surface of sphere of radius R
a. $4\pi R^2$
b. $\frac{3}{4}\pi R^2$
c. πR^2
d. $4\pi R^3$

25. The liquid surface in a cylindrical bucket of radius R rotating about its axis acquires a parabolic profile given by the equation $y = a + br^2$, where y is the height of the liquid surface from the bottom of the bucket at a radial distance r from the bucket axis. If the liquid has density ρ, then the mass of the liquid in the bucket is
a. $\pi\rho R^2\left(a - \frac{bR^2}{2}\right)$
b. $\pi\rho R^2\left(a + \frac{bR^2}{2}\right)$
c. $\pi\rho R^2 a$
d. $\pi\rho R^2\left(a + bR^2\right)$

26. The solution to the following equation is

$$x^2\frac{d^3y}{dx^3} + 2x\frac{d^2y}{dx^2} - 2\frac{dy}{dx} = 0$$

is given by
a. $y = C_1x + C_2x^{-2} + C_3$
b. $y = C_1x^2 + C_2x^{-2} + C_3$
c. $y = C_1x^2 + C_2x^{-1} + C_3$
d. $y = C_1x + C_2x^{-1} + C_3$

27. The value of the contour integral where C is the circle $|z| = 2$ is
a. $\frac{1}{2e}$
b. $\frac{1}{2}\left(\frac{1}{e} - \frac{1}{e^3}\right)$
c. zero
d. $\frac{1}{(2\pi i)e^3}$

28. The Newton-Raphson method is used to solve the equation, $(x-1)^3 + x - 3 = 0$. The method will fail in the very first iteration if the initial guess is
a. Zero
b. 0.5
c. 1
d. 3

numbers on the two faces) will show up exactly once ?

a. $\frac{121}{1728}$

b. $\frac{363}{1728}$

c. $\frac{121}{576}$

d. $\frac{363}{576}$

30. A company purchased components from three firms P, Q, and R as shown in the table below :

Firm	Total number of components purchased	Number of components likely to be defective
P	1000	5
Q	2500	5
R	500	2

The components are stored together. One of the components is selected at random and found to be defective. What is the probability that it was supplied by Firm R?

a. $\frac{1}{250}$

b. $\frac{1}{12}$

c. $\frac{1}{8}$

d. $\frac{1}{6}$

31. Match the following:

List I

A. Heat

B. Internal energy

C. Wo[illegible]

D. [illegible]tropy

List [illegible]

1. [illegible] Function

2. Path Function

	A	B	C	D
a.	2	1	1	1
b.	2	1	2	2
c.	2	2	1	1
d.	2	1	2	1

32. For a reversible exothermic gas phase reaction, A + B [illegible] C, the equilibrium conversion will increase with

b. decrease in pressure [illegible] in temperature

c. increase in pressure and [illegible] temperature

d. decrease in pressure and decrea[illegible] temperature

33. For a binary mixture of A and B at 400 K and 1 atm, which ONE of the following equilibrium states deviates signifi[illegible] from ideality?

Given:

$$\ln\left(P_A^{sat}\right) = 6.2 - \frac{2758}{T}$$

where

P_A^{sat} = vapor pres[illegible]ure of A, atm; T = temperature, K

P_A = partial pressure of A, atm

x_A = mol[illegible] fra[illegible]ion [illegible] A in liquid; y_A = mole fract[illegible] of [illegible] in vapor

a. [illegible] = 0.5; [illegible] = 0.25

b. [illegible] = 0.[illegible]; $p_A = 0.25$

c. x_A = 0.[illegible]; $p_A = 0.5$

d. [illegible] = 0.6; $y_A = 0.3$

34. Pur[illegible] A at 200°C is fed to a steady state a[illegible]abatic continuous reactor at the rate of 100 kg/hr where it undergoes an exothermic reaction to give its isomer B. The product stream is at temperature 500°C. The heat of reaction is 21 kJ/mol of A and the specific heat of the reaction mixture is constant at 35 J/(mol °C). The conversion in the reactor is

a. 25%

b. 50%

c. 75%

d. 100%

35. The molar density of water vapor at the normal boiling point of water is 33 mol/m^3. The compressibility factor under these conditions is close to which ONE of the following? R = 8.314 J/(mol K)

a. 0.75

b. 1

c. 1.25

d. 1.5

36. A liquid is pumped at the flow rate Q through a pipe of length L. The pressure drop of the fluid across the pipe is Δ P. Now a leak develops at the mid-point of the length of the pipe and the fluid leaks at the rate of Q/2. Assuming that the friction factor in the pipe remains unchanged, the

a. (1/2) ΔP
b. (5/8) ΔP
c. (3/4) ΔP
d. ΔP

37. In a laminar flow through a pipe of radius R, the fraction of the total fluid flowing through a circular cross-section of radius R/2 centered at the pipe axis is
a. 3/8
b. 7/16
c. 1/2
d. 3/4

38. A fluid obeying the constitutive equation

$$\tau = \tau_0 + K\left(\frac{dv_x}{dy}\right)^{\frac{1}{2}}, \tau > \tau_0$$

is held between two parallel plates a distance d apart. If the stress applied to the top plate is $3\tau_0$, then the velocity with which the top plate moves relative to the bottom plate would be
a. $2\left(\frac{\tau_0}{K}\right)^2 d$
b. $3\left(\frac{\tau_0}{K}\right)^2 d$
c. $4\left(\frac{\tau_0}{K}\right)^2 d$
d. $9\left(\frac{\tau_0}{K}\right)^2 d$

39. A bed fluidized by water is used for cleaning sand contaminated with salt. The particles of sand and salt have the same shape and size but different densities (ρ_{sand} = 2500 kg/m^3 and ρ_{salt} = 2000 kg/m^3). If the initial volume fraction of the salt in the mixture is 0.3 and if the initial value of the minimum fluidization velocity (U_{mf}) is 0.9 m/s, find the final value of the U_{mf} (in m/s) when the sand is washed free of the salt. Assume that the bed characteristics (bed porosity and solid surface area per unit volume) do not change during the operation and that the pressure drop per unit length is directly proportional to the fluid velocity
a. 0.70
b. 0.90
c. 1.00
d. 1.46

materials. The first one (with material density ρ_1) is solid, whereas the second (with material density ρ_2) is a hollow sphere with the inner shell diameter equal to half the outer diameter. If both the spheres have the same terminal velocity in any fluid, then the ratio of their material densities, ρ_2/ρ_1, is
a. 1
b. 8/7
c. 2
d. 8

41. A filtration is conducted at constant pressure to recover solids from dilute slurry. To reduce the time of filtration, the solids concentration in the feed slurry is increased by evaporating half the solvent. If the resistance of the filter medium is negligible, the filtration time will be reduced by a factor of
a. [illegible]
b. 2
c. [illegible]
d. [illegible]

42. One dimensional steady state heat transfer occurs from a flat vertical wall of length 0.1m into the adjacent fluid. The heat flux into this fluid is 21 W/m^2. The wall thermal conductivity is 1.73 W/(m K). If the heat transfer coefficient is 30 W/(m^2 K) and the Nusselt number based on the wall length is 20, then the magnitude of the temperature gradient at the wall on the fluid side (in K/m) is
a. 0.7
b. 12.14
c. 120
d. 140

43. Experiments conducted with a sparingly dissolving cylinder wall in a flowing liquid yielded the following correlation for the Sherwood number

$$Sh = 0.023\,(Re)^{0.83}\,(Sc)^{1/3}$$

Assuming the applicability of the Chilton-Colburn analog, the corresponding correlation for heat transfer is
a. $Sh = 0.023\,(Gr)^{0.83}\,(Pr)^{1/3}$
b. $Nu = 0.023\,(Re)^{0.83}\,(Pr)^{1/3}$
c. $j_H = 0.023\,(Re)^{0.83}\,(Pr)^{2/3}$
d. $Nu = 0.069\,(We)^{0.5}\,(Pr)^{4/3}$

44. A fluid flows through a cylindrical pipe under fully developed, steady state laminar

Assuming constant physical properties and negligible viscous heat dissipation, the governing equation for the temperature profile is (z, axial direction; r, radial direction)

a. $u_{max}\left[1-\left(\frac{r}{R}\right)^2\right]\left(\frac{\partial T}{\partial z}\right)=\frac{k}{\rho C_p}\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{\partial^2 T}{\partial z^2}\right]$

b. $u_{max}\left[1-\left(\frac{r}{R}\right)^2\right]\left(\frac{\partial T}{\partial r}\right)=\frac{k}{\rho C_p}\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial z}\right)+\frac{\partial^2 T}{\partial r^2}\right]$

c. $2u_{max}\left[1-\left(\frac{r}{R}\right)^2\right]\left(\frac{\partial^2 T}{\partial z^2}\right)=\frac{k}{\rho C_p}\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{\partial^2 T}{\partial r^2}\right]$

d. $u_{max}\left[1-\left(\frac{r}{R}\right)^2\right]\left(\frac{\partial T}{\partial z}\right)=\frac{k}{\rho C_p}\left[\frac{1}{z}\frac{\partial}{\partial z}\left(z\frac{\partial T}{\partial z}\right)+\frac{\partial^2 T}{\partial r^2}\right]$

45. An insulated cylindrical pipe of 0.2 m diameter has a surface temperature of 45°C. It is exposed to black body surroundings at 25°C. The emissivity and absorptivity of the insulation surface are 0.96 and 0.93, respectively. The convective heat transfer coefficient outside the insulation surface is 3.25 W/(m^2 K). The Stefan-Boltzmann constant is 5.67×10^{-8} W/(m^2 K^4). The surrounding fluid may be assumed to be transparent. Find the percentage contribution from radiation to the total heat transfer rate to the surroundings

a. 30.9
b. 50.0
c. 57.6
d. 68.4

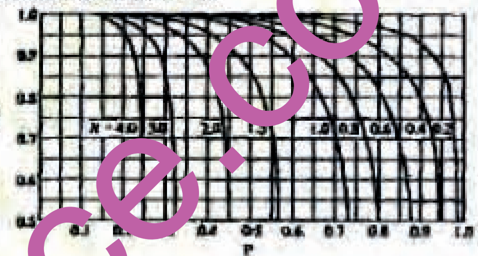
46. In a multistage countercurrent isothermal stripping column, feed containing 0.05 mol of solute/mol of solute free oil is treated with steam. The absorption factor A = 0.65. The equilibrium relation is given by $Y^* = 2X$, where Y^* and X refer to the equilibrium mole ratio in the steam and oil phases respectively. The Kremser equation is given as follows ('0' refers to liquid inlet at the top, 'N_p' refers to the last stage at the bottom).

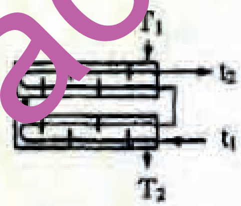
$$N_p=\frac{\log\left[\left(\frac{X_0-\frac{Y_{N_p+1}}{m}}{X_{N_p}-\frac{Y_{N_p+1}}{m}}\right)(1-A)+A\right]}{\log\left[\frac{1}{A}\right]}$$

If the steam is initially free of solute and its exit mole ratio (mol solute/mol steam) is 0.0624, then the number of equilibrium

a. 4.2
b. 5.2
c. 7.2
d. 8.2

47. A process fluid has to be cooled [illegible] 22°C to 2°C using brine in a 2-4 shell-[illegible] tube heat exchanger shown below. The brine enters at –3°C and leaves at 7°C. The overall heat transfer coefficient i[illegible]0 W/(m^2 K). The design heat load i[illegible] kW. The brine flows on the tube s[illegible] and the process fluid on the shell [illegible] the heat transfer area in m^2 is





$$P=\frac{t_2-t_1}{T_1-t_1}$$

$$R=\frac{T_1-T_2}{t_2-t_1}$$

a. 1.1
b. 5.77
c. 6.59
d. 7.53

48. 100 moles of a binary mixture F containing 60 mol% A (more volatile) and 40 mol% B is treated in a batch distillation still. After 1 hour, 70 moles of the distillate D is collected leaving behind the residue W. Relative volatility α is 2. The governing equation is

$$\log\frac{Fx_F}{Wx_w}=\alpha\log\frac{F(1-x_F)}{W(1-x_w)}$$

The average mole fraction of A in the distillate is

a. 0.43
b. 0.61
c. 0.69
d. 0.73

time t = τ without losing any mass. From the intestine, the drug is absorbed into blood. The rate of absorption is found to be proportional to the mass of the drug in the intestine with the proportionality constant k. Assuming no drug is lost from the blood, the total mass of the drug in the blood, M_b, at time t ≥ τ is given by

a. $M_b = M_0\left[1-exp\{-k(t-\tau)\}\right]$

b. $M_b = M_0\left[1-exp\{-kt\}\right]$

c. $M_b = M_0 \exp\{-k(t-\tau)\}$

d. $M_b = M_0\left[1-\exp\{-k(t+\tau)\}\right]$

50. The rate rat which an antiviral drug acts increases with its concentration in the blood, C, according to the equation

$$r = \frac{kC}{C_{50}+C}$$

where C_{50} is the concentration at which the rate is 50% of the maximum rate k. Often, the concentration C_{90}, when the rate is 90% of the maximum, is measured instead of C_{50}. The rate equation then becomes

a. $r = \frac{1.8kC}{(C_{90}+C)}$

b. $r = \frac{kC}{\left(\frac{C_{90}}{9}+C\right)}$

c. $r = \frac{kC}{C_{90}}$

d. $r = \frac{0.9kC}{C_{90}}$

51. Consider the following reactions between gas A and two solid spherical particles, B and C of the same size

$A + B \xrightarrow{1}$ gaseous product

$A + C \xrightarrow{2}$ ash

The ash does not leave the particle C. Let t_1 and t_2 be the times required for A to completely consume particles B and C, respectively. If k_1 and k_2 are equal at all temperatures and the gas phase mass transfer resistance is negligible, then

a. $t_1 = t_2$ at all temperatures

b. $t_1 = t_2$ at high temperatures

c. $t_1 > t_2$ at high temperatures

d. $t_1 < t_2$ at high temperatures

52. A reaction A→B is to be conducted in two ... as a function of conversion ... r = −1/(1 + X). If the feed conta... the conversion in the first ... minimizes the total volume of ... reactors is

a. $1-X_f$

b. $0.2X_f$

c. $0.5X_f$

d. $0.5(1-X_f)$

53. Consider the following elementary reaction network

The activation energies for the individual reactions are E_1 = 100 kJ/mol, E_2 = 150 kJ/mol, E_3 = 100 kJ/mol, and E_4 = 200 kJ/mol. If the feed is pure A and the desired product is C, then the desired temperature profile in a plug flow reactor in the direction of flow should be

a. constant at low temperature

b. constant at high temperature

c. increasing

d. decreasing

54. The exit age distribution in a stirred reactor is given by

$$E(t) = \frac{1}{\tau}e^{-\frac{t}{\tau}}$$

Fluid elements e_1 and e_2 enter the reactor at times t = 0 and t = θ > 0, respectively. The probability that e_2 exists the reactor before e_1 is

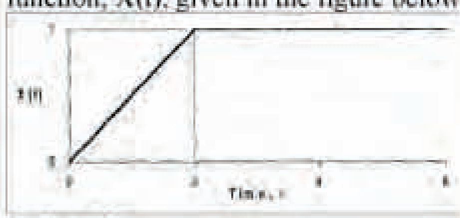
a. $\frac{1}{2}$

b. $\frac{1}{2}e^{-\theta/\tau}$

c. $e^{-\theta/\tau}$

d. zero

55. The Laplace transform of the input function, X(t), given in the figure below



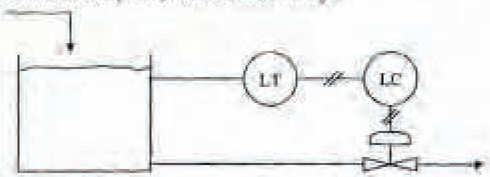
is given by

a. $\frac{1}{2s^2}\left(1-e^{-2s}\right)$

c. $\frac{1}{s^2}\left(1+e^{-2s}\right)$

d. $\frac{1}{s^2}\left(1-e^{-2s}\right)$

56. A liquid level control system is configured as shown in the figure below. If (he level transmitter ILT) is direct acting and the pneumatic control valve is air-to-open, what kind of control action should the controller (LC) have and why?



a. Direct acting since the control valve is direct acting
b. Reverse acting since the control valve is reverse acting
c. Direct acting since the control valve is reverse acting
d. Reverse acting since the control valve is direct acting

57. A 2-input, 2-output process can be described in the Laplace transform domain as given below

$$(\tau_1 s+1)Y_1(s)=K_1U_1(s)+K_2U_2(s)$$
$$(\tau_2 s+1)Y_2(s)=K_3U_2(s)+K_4[illegible]$$

where U_1 and U_2 are the inputs and Y_1 and Y_2 are the outputs. The ga[illegible]s o[illegible] the transfer functions $Y_1(s)$/[illegible] and $Y_2(s)/U_2(s)$, respectivel[illegible]

a. K_2 and K_3
b. K_1 and $K_3 + K_2K_4$
c. K_2 and $K_3 +$ [illegible]$_1K_4$
d. K_2 and K[illegible] [illegible] K_4

58. A process is pe[illegible]rbed by a sinusoidal input, u[illegible]) = [illegible]not. The resulting process outp[illegible] $Y(s)=\frac{kA\omega}{(\tau s+1)(s^2+\omega^2)}$. If y(0) [illegible] 0, th[illegible] differential equation representing [illegible] process is

a. $\frac{dy(t)}{dt}+\tau y(t)=Ku(t)$

b. $\tau\frac{dy(t)}{dt}+y(t)=KAu(t)$

c. $\tau\frac{dy(t)}{dt}+y(t)=Ku(t)$

d. [illegible]

59. A weighing machine is ca[illegible]°C and the output reading R (in [illegible] to the weight W (in kg) by the e[illegible]

R = sW

where the sensitivity s = 20 mm/kg[illegible] temperature of 30°C, the weigh[illegible] machine undergoes a zero drift (change in instrument output reading at zero value of weight) of +2 mm and its sens[illegible] changes to 20.5 mm/kg. The [illegible]hing machine when used at 30°C show[illegible] a reading of 50 mm. The true [illegible] (in kg) of the object is

a. 2.34
b. 2.40
c. 2.44
d. 2.50

60. In a desal[illegible] plant, an evaporator of area 200 m² was purchased in 1996 at a cost [illegible]00,000. In 2002, another eva[illegible]rator [illegible]f area 50m² was added. What [illegible] co[illegible] of the second evaporator (in)? A[illegible]me that the cost of evaporator scales [illegible]s ([illegible]apacity)$^{0.54}$. The Marshall and Swift [illegible]ex was 1048.5 in 1996 and 1116.9 in 2002.

a. 1,30,500
b. 1,39,100
c. 1,41,900
d. 1,51,200

61. The mixing of rubber latex solution was studied in an unbaffled mixer in the laboratory. The mixer was equipped with a six blade turbine impeller. A tyre company scales this process up using a baffled tank. The baffled tank has 3 times the diameter of the lab scale mixer. It uses the same type of impeller operated at the same speed. The relevant shape factors are also the same. Assuming that laminar conditions prevail in both cases, the power requirement in the industrial scale mixer

a. is 3 times that of the lab scale mixer
b. is 9 times that of the lab scale mixer
c. is 27 times that of the lab scale mixer
d. cannot be estimated reliably due to the presence of baffles

62. Due to a 20% drop in the product selling price, the pay-back period of a new plant increased to 1.5 times that estimated initially, the production cost and the production rate remaining unchanged. If [illegible]

a. 0.2
b. 0.4
c. 0.5
d. 0.6

63. Obtain the optimal diameter of a cylindrical storage vessel of volume V. The curved shell costs C_s (in Rs/m^2), and the flat top and bottom plates cost C_p (in Rs/m^2)

a. $D = \frac{C_s}{C_p}\left[\frac{4V}{\pi}\right]^{\frac{1}{3}}$

b. $D = \left[\frac{8VC_s}{\pi C_p}\right]^{\frac{1}{3}}$

c. $D = \left[\frac{VC_s}{C_p}\right]^{\frac{1}{3}}$

d. $D = \left[\frac{4VC_s}{\pi C_p}\right]^{\frac{1}{3}}$

64. A sale contract signed by a chemical manufacturer is expected to generate a net cash flow of Rs. 2,50,000/- per year at the end of each year for a period of three years. The applicable discount rate (interest rate) is 10%. The net present worth of the total cash flow is Rs.

a. 7,50,000
b. 6,83,750
c. 6,21,500
d. 3,32,750

65. A saturated vapor is fed to a distillation column at 180 kmol/hr. Both the rectifying and stripping sections of the column operate at 60% of their respective flooding velocities. The flooding velocity of the rectifying section is twice that of the stripping section. The assumptions of constant molar overflow and constant molar vapor density throughout the column are valid. If the boil-up rate is 60 kmol/hr, then the relationship between the diameters of the rectifying section (d_r) and the stripping section (d_s) is

a. $d_r = \sqrt{2}\, d_s$
b. $d_r = \sqrt{3}\, d_s$
c. $d_r = 2d_s$
d. $d_r = 3d_s$

66. Pair the following industrial processes with the catalysts used

List I

A. Oxidation of o-xylene to phthalic anhydride
B. Oxidation of ethanol to acetaldehyde
C. Oxidation of ammonia to oxides of nitrogen

List II

1. V_2O_5
2. Pd
3. Ag
4. Pt

	A	B	C
a.	1	2	4
b.	2	1	4
c.	4	3	1
d.	1	3	2

67. Pair the following reactors with their products

List I

A. Arc Furnace
B. Fermenter
C. Hydrogenator

List II

1. Citric acid
2. Calcium carbide
3. Saturated fats
4. Alum

	A	B	C
a.	4	1	3
b.	2	1	3
c.	4	3	1
d.	2	3	1

68. Pair the following polymers with their chain characteristics

List I

A. HDPE
B. LDPE
C. LLDPE

List II

1. Very few branches
2. Short and regular branches
3. High branching with both short and long chain branches

	A	B	C
a.	1	2	3
b.	2	1	3
c.	1	3	2
d.	2	3	1

69. Choose the most appropriate pairs from the following

List I

A. Nitration
B. Sulphonation
C. Carbonation

1. Detergent
2. Pulp and paper
3. Explosives
4. Sugar

	A	B	C
a.	1	2	4
b.	3	1	2
c.	3	1	4
d.	3	2	4

70. Match the following

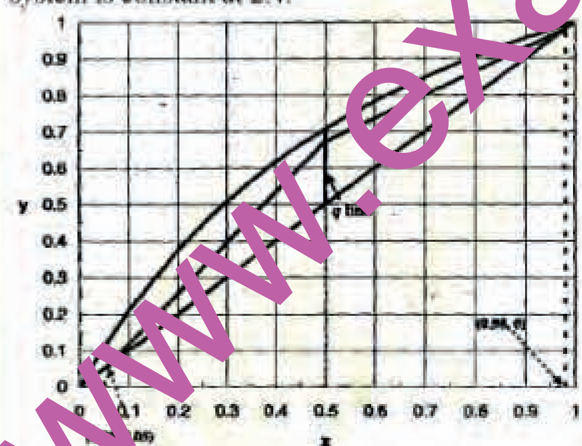
List I
A. Carbon disulphide
B. Caprolactum
C. Gypsum

List II
1. Nylon-6
2. Nylon-66
3. Phosphoric acid
4. Viscose rayon

	A	B	C
a.	4	2	3
b.	2	1	3
c.	3	1	4
d.	4	1	3

Common Data for Questions (71,72 &73)

A binary distillation column separates 100 mol/hr of a feed mixture into distillate D and residue W. The McCabe-Thiele diagram for this process is given below. The relative volatility for the binary system is constant at 2.4.



71. The distillate and residue flow rates (in mol/hr) are
a. D = 48.4, W = 51.6
b. D = 51.6, W = 48.4
c. D = 54.7, W = 45.3
d. D = 45.3, W = 54.7

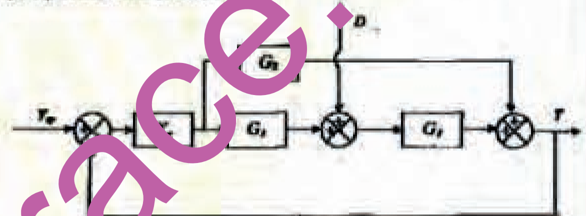
72.

a. 0.64
b. 1.00
c. 1.55
d. 1.80

73. The minimum number of theoretical stages (inclusive of reboiler) for this process is
a. 5.2
b. 6.1
c. 7.8
d. infinite

Common Data for Questions (74 & 75)

The block diagram of a closed loop control system is shown in the figure below. Y is the controlled variable, D is disturbance, Y_s is the set point, G_1, G_2, and G_3, are transfer functions, and K is the proportional controller.



74. The closed loop transfer function Y(s)/D(s) is given by

a. $\frac{G_1G_3}{1+(G_1G_3+G_2)K_c}$

b. $\frac{G_1}{1+(G_1G_3+G_2)K_c}$

c. $\frac{G_3}{1+(G_1+G_2)G_3K_c}$

d. $\frac{G_3}{1+(G_1G_3+G_2)K_c}$

75. Let $G_1(s) = 1$ and $G_2(s) = G_3(s) = 1/(s+1)$. A step change of magnitude M is made in the set point. The steady state offset of the closed loop response Y is

a. $\frac{M}{1+2K_c}$

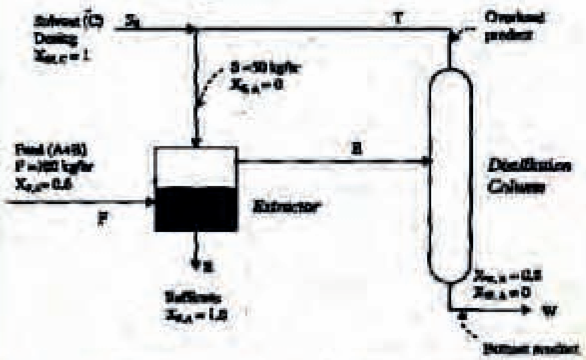
b. $\frac{M}{1+K_c}$

c. $\frac{M(K_c-1)}{1+2K_c}$

d. zero

Statement for Linked Answer

Solvent C is used to extract solute B selectively from 100 kg/hr feed mixture A+B in a steady state continuous process shown below. The solubility of C in the raffinate and the solubility of A in the extract are negligible. The extract is distilled to recover B in the bottom product. The overhead product is recycled to the extractor. The loss of solvent in the bottoms is compensated by make up solvent S_d. The total flow rate of the solvent stream S going to the extractor is 50 kg/hr. The mass fractions (X_i's) of some selected streams are indicated in the figure below.



76. Distillation bottoms flow rate W and solvent dosing rate 5d in kg/hr are
   a. W = 50, S_d = 50
   b. W =100, S_d = 20
   c. W = 10, S_d = 50
   d. W= 50, Sd = 10
77. Feed rate E to the distillation column and overhead product rate T in kg/hr are
   a. E = 90,T = 40
   b. E = 80, T = 40
   c. E = 90, T = 50
   d. E = 45, T = 20

Statement for Linked Answer Question (78 and 79)

A continuous grinder obeying the Bond crushing law grinds a solid at the rate of 1000 kg/hr from the initial diameter of 10 mm to the final diameter of 1 mm.

78. If the market now demands particles of size 0.5 mm, the output rate of the grinder (in kg/hr) for the same power input would be reduced to
   a. 227
   b. 474
   c. 623
   d. 856
79. In order to restore the output back to 1000

The two grinders can be connected in series (configuration-1) or in parallel (configuration-2). Compare the two configurations in terms of the additional power consumption over the case above
   a. configuration-1 consumes less power than configuration-2
   b. configuration-2 consumes less power than configuration-1 both configurations consume the same power
   c. configuration-2 consumes less or more power than configuration-1 depending on how the feed is distributed between the two grinders in configuration-2 (the parallel configuration)

Statement for Linked Answer Question (80 and 81)

Consider the diffusion of a reactant A through a cylindrical catalyst pore of radius R and length L>>R. Reactant A undergoes a zeroth order reaction on the cylindrical surface of the pore. The following equation describes changes in the concentration of A within the pore due to the axial diffusion of A and the disappearance of A due to reaction

$$\frac{d^2 c_A}{dx^2} = K$$

where c_A is the concentration of A at a distance x from the pore entrance, and K is a constant.

80. If the concentration of A at the pore entrance (x = 0) is C_{AO}, and x = L is a dead end where no reaction occurs, the concentration profile of A in the pore is given by
   a. $c_A(x) = \frac{Kx^2}{2} - KLx + c_{A0}$
   b. $c_A(x) = \frac{Kx(x-L)}{2} - c_{A0}\frac{x}{L} + c_{A0}$
   c. $c_A(x) = c_{A0}$
   d. $c_A(x) = c_{A0}\left(\frac{L-x}{L}\right)$
81. The minimum pore length for A to be completely converted within the pore is
   a. $\left(\frac{c_{A0}}{K}\right)^{1/2}$
   b. $\left(\frac{c_{A0}}{\right)^{1/2}$

c. $\left(\frac{2c_{40}}{K}\right)$

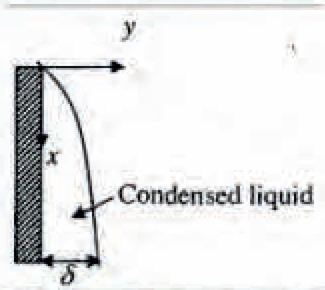
d. $\left(\frac{2c_{40}}{K}\right)^{1/2}$

Statement for Linked Answer Question (82 and 83)

In film condensation on a vertical plane surface, the x directional velocity distribution is given by

$$u(y)=\frac{g(\rho_l-\rho_v)}{\mu_l}\left(\delta y-\frac{1}{2}y^2\right)$$

where δ is the film thickness at any x.



82. The mass flow rate of the condensate m(x) through any axial position x per unit width of the plate is given by

a. $m(x)=\frac{g\rho_l(\rho_l-\rho_v)\delta^3}{3\mu_l}$

b. $m(x)=\frac{g(\rho_l-\rho_v)\delta^2}{3\mu_l}$

c. $m(x)=\frac{g\rho_v^2-\delta^3}{\mu_l}$

d. $m(x)=\frac{g\rho_l(\rho_v)\delta}{\mu_l}$

83. Differentiate m(x) with respect to δ to get the differential increase in condensate mass dm with film thickness i.e., dm/dδ. Then obtain dm/dx assuming heat flux through the film to be due to conduction based on a linear temperature profile between the vapor and wall. Hence determine dδ/dx.

Here μ_l is liquid viscosity, k_l is thermal conductivity, and λ is latent heat of condensation. T_v is the vapor temperature and T_W is the wall temperature.

a. $\frac{d\delta}{dx}=\frac{\mu_l k_l(T_v-T_w)}{g\rho_l(\rho_l-\rho_v)\lambda}\frac{1}{\delta^2}$

b. $\frac{d\delta}{dx}=\frac{\mu_l k_l(T_v-T_w)}{g\rho_v(\rho_l-\rho_v)\lambda}\frac{1}{\delta^3}$

c. $\frac{d\delta}{dx}=\frac{\mu_l(T_v-T_w)}{g\rho_l k_l(\rho_l-\rho_v)\lambda}\frac{1}{\delta^2}$

d. $\frac{d\delta}{dx}=\frac{\mu_l k_l(T_v-T_w)}{g\rho_v(\rho_l-\rho_v)\lambda}\frac{1}{\delta}$

Statement for Linked Answer Question (84 and 85)

For the system shown below, $G_1(s)=\frac{1}{\tau_1 s+1}$, $G_2(s)=\frac{1}{\tau_2 s+1}$ and $\tau_2=1\tau_1$

When the system is excited by the sinusoidal input X(t) = sinωt, the intermediate response Y is given by

$$Y=A\sin(\omega t+\phi)$$

84. If the response of Y lags behind the input X by 45° and τ_1 = 1, then the input frequency ω is

a. 1

b. $\frac{\pi}{4}$

c. zero

d. –1

85. For the same input, the amplitude of the output Z will be

a. 1.00

b. 0.62

c. 0.42

d. 0.32