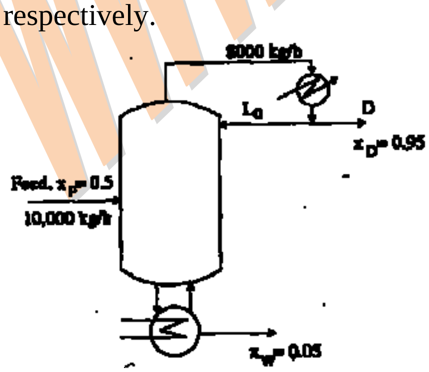
CHEMICAL ENGINEERING

ONE MARKS QUESTIONS (1-30)

1. The inverse Laplace transform of the function $f(s) = \dfrac{1}{s(1+s)}$ is
   a. $1 + e^{t}$
   b. $1 - e^{t}$
   c. $1 + e^{-t}$
   d. $1 - e^{-t}$
2. The function f(x) = 3x(x–2) has a
   a. minimum at x = 1
   b. maximum at x =
   c. minimum at x = 2
   d. maximum at x = 2
3. The complex number 2(1 + i) can be represented in polar form as
   a. $2\sqrt{2}e^{i\pi/4}$
   b. $\dfrac{\pi}{4}e^{i2\sqrt{2}}$
   c. $\sqrt{2}e^{i\pi/4}$
   d. $\dfrac{\pi}{4}e^{i\sqrt{2}}$
4. The differential equation $\dfrac{d^2y}{dx^2} + \sin x\dfrac{dy}{dx} + ye^{x} = \sinh x$ is
   a. first order and linen
   b. first order and non-linear
   c. second order and linear
   d. second order and non-linear
5. A distillation column separates 10,000 kg/h of a benzene-toluene mixture as shown in the figure below. In the figure x_F, x_D, and x_w represent the weight fraction of benzene in the feed, distillate, and residue, respectively.



   The reflux ratio is
   a. 0.5
   b. 0.6
   c. 1.0
   d. 2.0
6. The weight fraction of methanol in an aqueous solution is 0.64. The mole fraction of methanol x_M satisfies
   a. $x_M = 0.5$
   b. $x_M < 0.5$
   c. $0.5 < x_M < 0.64$
   d. $x_M \geq 0.64$
7. For an ideal gas mixture undergoing a reversible gaseous phase chemical reaction, the equilibrium constant
   a. is independent of pressure
   b. increases with pressure
   c. decreases with pressure
   d. increases/decreases with pressure depending on the stoichiometric coefficients of the reaction
8. As pressure approaches zero, the ratio of fugacity to pressure (f/P) for a gas approaches
   a. zero
   b. unity
   c. infinity
   d. an indeterminate value
9. A perfectly insulated container of volume V is divided into two equal halves by a partition. One side is under vacuum while the other side has one mole of an ideal gas (with constant heat capacity) at 298 K. If the partition is broken, the final temperature of the gas in the container
   a. will be greater than 298 K
   b. will be 298 K
   c. will be less than 298 K
   d. cannot be determined
10. The rate expression for the gaseous phase reaction $CO + 2H_2 \Leftrightarrow CH_3OH$ is given by
    $r = k_1 p_{CO}^{\alpha} p_{H_2}^{\beta} - k_2 p_{CH_2OH}^{\gamma}$
    Which of the following is NOT possible?
    a. $\alpha = 1, \beta = 1, \gamma = 1$
    b. $\alpha = 1, \beta = 2, \gamma = 1$
    c. $\alpha = 1/3, \beta = 2/3, \gamma = 1/3$
    d. $\alpha = 1/2, \beta = 1, \gamma = 1/2$
11. The equivalent diameter for flow through a rectangular duct of width Band height H is

a. $\frac{HB}{2(H+B)}$
b. $\frac{HB}{(H+B)}$
c. $\frac{2HB}{(H+B)}$
d. $\frac{4HB}{(H+B)}$

12. What is the force required (in Newtons) to hold a spherical balloon stationary in water at a depth of H from the air-water interface? The balloon is of radius 0.1 in and is filled with air.
a. $\frac{4\pi g}{3}$
b. $\frac{0.1\pi gH}{4}$
c. $\frac{0.1\pi gH}{8}$
d. $\frac{0.04\pi gH}{3}$

13. Match the systems in Group I with equipment used to separate them in Group II
Group I
A. gas - solid
B. liquid - liquid
Group II
1. filter press
2. cyclone
3. decanter
4. thickener

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

14. For a cyclone of diameter 0.2 in with a tangential velocity of 15 m/s at the wall, the separation factor is
a. 2250
b. 1125
c. 460
d. 230

15. For a particle settling in water at its terminal settling velocity, which of the following is true?
a. buoyancy = weight + drag
b. weight = buoyancy + drag
c. drag = buoyancy + weight
d. drag = weight

16. In constant pressure filtration,
a. resistance decreases with time
b. rate of filtration is constant
c. rate of filtration increases with time
d. rate of filtration decreases with time

17. In forced convection, the Nusselt number Nu is a function of
a. Re and Pr
b. Re and Gr
c. Pr and Gr
d. Re and Sc

18. For an ideal black body
a. absorptivity = 1
b. reflectivity = 1
c. emissivity = 0
d. transmissivity = I

Common Data for Questions (19 & 20)

Pure aniline is evaporating through a stagnant air film of 1 mm thickness at 300 K and a total pressure of 100 kPa. The vapour pressure of aniline at 300 K is 0.1 kPa. The total molar concentration under these conditions is 40.1 mol/m^3. The diffusivity of aniline in air is 0.74×10^{-5} m^2/s.

19. The numerical value of the mass transfer coefficient is 7.4×10^{-3} . Its units are
a. m/s
b. cm/s
c. $mol/(m^2\ s\ Pa)$
d. $kmol/(m^2\ s\ Pa)$

20. The rate of evaporation of aniline is 2.97×10^{-4}. Its units are
a. mol/s
b. $mol/(cm^2\ s)$
c. $mol/(m^2\ s)$
d. $kmol/(m^2\ s)$

Common Data for Questions (21 & 22)

An air-water vapour mixture has a dry bulb temperature of 60 °C and a dew point temperature of 40 °C. The total pressure is 101.3 kPa and the vapour pressures of water at 40°C and 60°C are 7.30 kPa and 19.91 kPa, respectively.

21. The humidity of air sample expressed as kg of water vapour/kg of dry air is
a. 0.048
b. 0.079
c. 0.122
d. 0.152

22. The wet bulb temperature T_w for the above mixture would be
a. less than 40°C
b. 40°C
c. 40°C < T_w < 60°C
d. 60°C

23. The rate of ammonia synthesis for the reaction $N_2 + 3H_2 \Leftrightarrow NH_3$ is given by $r = 0.8 p_{N_2} p_{H_2}^3 - 0.6 p_{NH_3}^2$. If the reaction is represented as , $\frac{1}{2}N_2 + \frac{3}{2}H_2 \Leftrightarrow NH_3$ the rate of ammonia synthesis is
a. $r = 0.8 p_{N_2}^{0.5} p_{H_2}^{1.5} - 0.6 p_{NH_3}$
b. $r = 0.8 p_{N_2} p_{H_2}^3 - 0.6 p_{NH_3}^2$
c. $r = 0.5\left(0.8 p_{N_2} p_{H_2}^3 - 0.6 p_{NH_3}^2\right)$
d. $r = 0.5\left(0.8 p_{N_2}^{0.5} p_{H_2}^{1.5} - 0.6 p_{NH_3}^2\right)$

24. An endothermic aqueous phase first order irreversible reaction is carried out in an adiabatic plug flow reactor. The rate of reaction
a. is maximum at the inlet of the reactor
b. goes through a maximum along the length of the reactor
c. goes through a minimum along the length of the reactor
d. is maximum at the exit of the reactor

25. A first order gaseous phase reaction is catalyzed by a non-porous solid. The kinetic rate constant and the external mass transfer coefficient are k and k_g, respectively. The effective rate constant (k_{eff}) is given by
a. $k_{eff} = k + k_g$
b. $k_{eff} = \frac{\left(k + k_g\right)}{2}$
c. $k_{eff} = \left(k\, k_g\right)^{1/2}$
d. $\frac{1}{k_{eff}} = \frac{1}{k} + \frac{1}{k_g}$

26. For a packed bed reactor, the presence of a long tail in the residence time distribution curve is an indication of
a. ideal plug flow
b. bypass
c. dead zone
d. channeling

27. For the time domain function f(t) = t the Laplace transform of $\int_0^t f(t)dt$ is given by
a. $1/(2s^3)$
b. $2/s^3$
c. $1/s^3$
d. $2/s^3$

28. Acetone is to be removed from air in an isothermal dilute absorber using pure water as solvent. The incoming air contains 5 mol% of acetone (y_{in} = 0.05). The design equation to be used for obtaining the number of trays (N) of the absorber is

$$N + 2 = 6\log\left(\frac{y_{in}}{y_{out}}\right)$$

For 98% recovery of acetone, the number of trays required is/are
a. 1
b. 8
c. 9
d. 10

29. Prilling tower is found in the flowsheet for the manufacture of
a. ammonia
b. urea
c. superphosphate
d. triple superphosphate

30. The proper arrangement of the petroleum fractions, in the order of their boiling points is
a. lubricating oils > diesel > petrol > LPG
b. lubricating oils > petrol > diesel > LPG
c. petrol > lubricating oils > diesel > LPG
d. petrol > diesel > LPG > lubricating oil

TWO MARKS QUESTIONS (31-90)

31. The sum of the eigenvalues of the matrix $\begin{pmatrix} 3 & 4 \\ x & 1 \end{pmatrix}$ for real and negative values of x is
a. greater than zero
b. less than zero
c. zero
d. dependent on the value of x

32. The system of equations

$$4x + 6y = 8$$
$$7x + 8y = 9$$
$$3x + 2y = 1$$

has

a. no solution
b. only one solution
c. two solutions
d. infinite number of solutions

33. A box contains three blue balls and four red balls. Another identical box contains two blue balls and five red balls. One ball is picked at random from one of the two boxes and it is red. The probability that it came from the first box is
a. 2/3
b. 4/9
c. 4/7
d. 2/7

34. The series
$$\sum_{n=1}^{\infty} \frac{(z+2)^n}{n!}$$
converges for
a. all z
b. z >2
c. |z| >2
d. |z| < 2

35. The differential equation for the variation of the amount of salt x in a tank with time t is given by $\frac{dx}{dt} + \frac{x}{20} = 10$. x is in kg and t is in minutes. Assuming that there is no salt in the tank initially, the time (in mm) at which the amount of salt increases to 100 kg is
a. 10 ln 2
b. 20 ln 2
c. 50 ln 2
d. 100 ln 2

36. Value of the integral
$$\int_{-2}^{2} \frac{dx}{x^2} \text{ is}$$
a. 0
b. 0.25
c. 1
d. ∞

37. The differential equation can be reduced to
$$\left(\frac{dy}{dx}\right)^2 + y\frac{d^2y}{dx^2} = 0$$
(where α is a constant)
a. $\left(\frac{dy}{dx}\right)^2 = \alpha - \frac{3y^2}{2}$
b. $\left(\frac{dy}{dx}\right)^2 = \alpha - 2y$
c. $\frac{dy}{dx} = \frac{\alpha}{y^2}$
d. $\frac{dy}{dx} = \frac{\alpha}{y}$

38. The value of
$$\lim_{x\to 9} \frac{\sqrt{x}-3}{x^2-81} \text{ is}$$
a. 0
b. 1/27
c. 1/108
d. ∞

39. 80 kg of Na_2SO_4 (molecular weight = 142) is present in 330 kg of an aqueous solution. The solution is cooled such [hat 80kg of $Na_2SO_4.10H_2O$ crystals separate out. The weight fraction of Na_2SO_4 in the remaining solution is
a. 0.00
b. 0.18
c. 0.24
d. 1.00

Common Data for Questions (40 & 41)

One mole of methane undergoes complete combustion in a stoichiometric amount of air. The reaction proceeds as $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. Both the reactants and the products are in gas phase.
$\Delta H^0_{298} = -730$ kJ/mol of methane.

40. Mole fraction of water vapour in the product gases is about
a. 0.19
b. 0.33
c. 0.40
d. 0.67

41. If the average specific heat of all the gases/vapour is 40 J/(mol K). the maximum temperature rise of the exhaust gases in °C would be approximately equal to
a. 1225
b. 1335
c. 1525
d. 1735

42. A vessel of volume 1000 m^3 contains air which is saturated with water vapour. The total pressure and temperature are 100 kPa and 20 °C, respectively. Assuming that the vapour pressure of water at 20°C is 2.34

kPa, the amount of water vapour (in kg) in the vessel is approximately

a. 17
b. 20
c. 25
d. 34

43. The number of degrees of freedom for an azeotropic mixture in a two component vapour- liquid equilibria is/are

a. zero
b. one
c. two
d. three

44. A car tyre of volume. 0.057 m^3 is inflated to 300 kPa at 300 K. After the car is driven for ten hours, the pressure in the tyre increases to 330 kPa. Assume air is an ideal gas and C_v for air is 21 J/(mol K). The change in the internal energy of air in the Lyre in J/mol is

a. 380
b. 630
c. 760
d. 880

45. A gas obeys P(v-b) = RT. The work obtained from reversible isothermal expansion of one mole of this gas from an initial molar volume v_i to a final molar volume v_f, is

a. $RT\ln\left(\frac{v_f}{v_i}\right)$

b. $RT\ln\left(\frac{v_f-b}{v_i}\right)$

c. $RT\ln\left(\frac{v_f}{v_i-b}\right)$

d. $RT\ln\left(\frac{v_f-b}{v_i-b}\right)$

46. A cyclic engine exchanges heat with two reservoirs maintained at 100 and 300 °C, respectively. The maximum work (in J) that can be obtained from 1000 J of heat extracted from the hot reservoir is

a. 349
b. 651
c. 667
d. 1000

47. The vapour pressure of water is given by

In $P^{sat} = A - \frac{5000}{T}$ where A is a constant, P^{sat} is vapour pressure in atm, and T is temperature in K. The vapour pressure of water in atm at 50 °C is approximately

a. 0.07
b. 0.09
c. 0.11
d. 0.13

48. At standard conditions,

$$N_2 + 2O_2 \Leftrightarrow 2NO_2 \qquad \Delta G^0 = 100 kJ/mol$$

$$NO + \frac{1}{2}O_2 \Leftrightarrow 2NO_2 \qquad \Delta G^0 = -35 kJ/mol$$

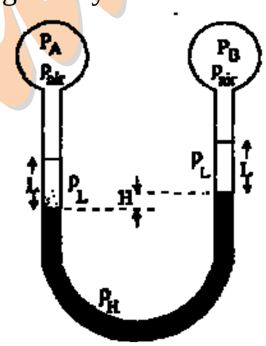
The standard free energy of formation of NO in kJ/mol is

a. 15
b. 30
c. 85
d. 170

49. Viscosity of water at 40°C lies in the range of

a. $1\times10^{-3} - 2\times10^{-3}$ kg/(m s)
b. $0.5\times10^{-3} - 1\times10^{-3}$ kg/(m s)
c. 1 – 2 kg/(m s)
d. 0.5 – 1 kg/(m s)

50. For the manometer setup shown in the figure, the pressure difference PA- PB is given by



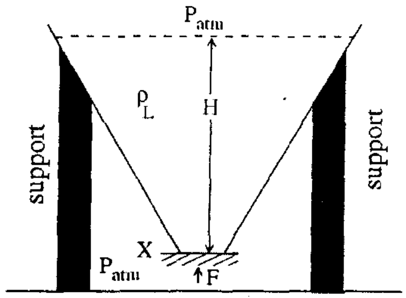
a. $(\rho_H - \rho_{air})gH$

b. $(\rho_H - \rho_L)gH$

c. $(\rho_H - \rho_L)gH + (\rho_L - \rho_{air})g(L-H)$

d. $(\rho_H - \rho_L)gL + (\rho_L - \rho_{air})gH$

51. A conical tank with a bottom opening of cross-sectional area A is filled with water and is mounted on supports, as shown in the figure. What is the force F with which plate X must be pushed up to prevent water from leaking? Assume that the density of air is negligible as compared to the density of water ρ_L .



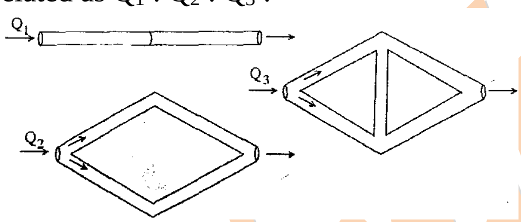
a. $\rho_L Vg$

b. $\rho_L AHg$

c. $\rho_L Vg/2$

d. $\rho_L Vg/3$

52. Three piping networks, as shown in the figure, are placed horizontally. They are made using identical pipe segments and are subjected to the same pressure drop across them.
Assuming no pressure losses at junctions, the flow rates across the three networks are related as $Q_1 : Q_2 : Q_3$:



a. $1 : \sqrt{3} : 2$

b. $1 : 2 : 3$

c. $1 : 2 : 2$

d. $1 : \sqrt{2} : \sqrt{2}$

53. To keep the power input constant for a stirred vessel operating under fully developed turbulent flow conditions (constant power number), if the impeller diameter is increased by 20%, the impeller speed should be decreased by a factor of

a. $(1.2)^{3/2}$

b. $(1.2)^{3/5}$

c. $(1.2)^{2/3}$

d. $(1.2)^{5/3}$

54. A centrifugal filtration unit operating at a rotational speed of ω has inner surface of the liquid (density ρ_L) located at a radial distance R from the axis of rotation. The thickness of the liquid film is δ and no cake is formed. The initial pressure drop during filtration is

a. $\frac{1}{2}\omega^2 R^2 \rho_L$

b. $\frac{1}{2}\omega^2 \delta^2 \rho_L$

c. $\frac{1}{2}\omega^2 \delta \rho_L (2R+\delta)$

d. $\frac{1}{2}\omega^2 R \rho_L (R+2\delta)$

55. U_{mf} is the minimum fluidisation velocity for a bed of particles. An increase in the superficial gas velocity from $2U_{mf}$ to $2.5U_{mf}$ results in (all velocities are smaller than the entrainment velocity of the particles) no change in

a. drag on particles

b. drag on column walls

c. the bed height

d. the bed voidage

56. The Kozney-Carman equation, rewritten in terms of non—dimensional numbers, gives $\left(\frac{\Delta P}{\rho u^2}\right)$ proportional to

a. $\frac{(L/D_P)}{\text{Re}}$

b. $\frac{\text{Re}}{(D_P/L)}$

c. $\frac{(L/D_P)}{\text{Re}^2}$

d. $\frac{\text{Re}^2}{(D_P/L)}$

57. The cumulative mass fraction of particles smaller than size d_j for a collection of N_i particles of diameter d_i, and mass m_i (i = 1, 2, 3, .., ∞) is given by

a. $\sum_{i=1}^{j} N_i d_i^3 \Big/ \sum_{i=1}^{\infty} N_i d_i^3$

b. $\sum_{i=1}^{j} N_i m_i d_i^3 \Big/ \sum_{i=1}^{\infty} N_i m_i d_i^3$

c. $\sum_{i=1}^{j} N_i m_i d_i^2 \Big/ \sum_{i=1}^{\infty} N_i m_i d_i^2$

d. $\sum_{i=1}^{j} N_i m_i d_i \Big/ \sum_{i=1}^{\infty} N_i m_i d_i$

58. The left face of a one dimensional slab of thickness 0.2 in is maintained at 80°C and the right face is exposed to air at 30°C. The thermal conductivity of the slab is 1.2 W/(m K) and the heat transfer coefficient from the right face is 10 W/(m^2 K). At steady state, the temperature of the right face in °C is
a. 77.2
b. 71.2
c. 63.8
d. 48.7

59. A metal ball of radius 0.1 m at a uniform temperature of 90°C is left in air at 30°C. The density and the specific heat of the metal are 3000 kg/m^3 and 0.4 kJ/(kg K), respectively. The heat transfer coefficient is 50 W/(m^2 K). Neglecting the temperature gradients inside the ball, the time taken (in hours) for the ball to cool to 60 °C is
a. 555
b. 55.5
c. 0.55
d. 0.15

60. It is desired to concentrate a 20% salt solution (20 kg of salt in 100 kg of solution) to a 30% salt solution in an evaporator. Consider a feed of 300 kg/mm at 30 °C. The boiling point of the solution is 110 °C, the latent heat of vaporization is 2100 kJ/kg, and the specific heat of the solution is 4 kJ/(kg K). The rate at which heat has to be supplied (in kJ/min) to the evaporator is
a. 3.06×10^5
b. 6.12×10^5
c. 7.24×10^5
d. 9.08×10^5

61. Hot water (0.01 m^3/min) enters the tube side of a cocurrent shell and tube heat exchanger at 80 °C and leaves at 50°C. Cold oil (0.05 m^3/min) of density 800 kg/m^3 and specific heat of 2 kJ/(kg K) enters at 20 °C. The log mean temperature difference in °C is approximately
a. 32
b. 37
c. 45
d. 50

Common Data for Questions (62 & 63)

The boiling points for pure water and pure toluene are 100°C and 110.6 °C, respectively. Toluene and water are completely immiscible in each other. A well agitated equimolar mixture of toluene and water is prepared.

62. The temperature at which the above mixture will exert a pressure of one standard atm is
a. less than 100°C
b. 100°C
c. between 100 and 110°C
d. 110.6°C

63. At a total pressure of one standard atm exerted by the vapours of water and toluene, the mole fraction of water x_w in the vapour phase satisfies
a. $0 < x_w < 0.5$
b. $x_w = 0.5$
c. $0.5 < x_w < 1.0$
d. $x_w = 1.0$

64. In a distillation operation, what is the effect of the temperature of the reflux stream (given below) on the condenser and reboiler loads?
Reflux conditions:
(i) reflux stream is completely liquid and is at its bubble point
(ii) reflux stream is below its bubble point
a. condenser and reboiler loads are the same in both the cases
b. reboiler load is the same in both the cases but condenser load is higher in case (ii)
c. condenser load is the same in both the cases but reboiler load is higher in case (ii)
d. both condenser and reboiler loads are higher in case (ii) as compared to case (i)

65. A long cylinder and a sphere both of 5 cm diameter are made from the same porous material. The flat ends of cylinder are sealed. Both the cylinder and sphere are saturated with the same solution of sodium chloride. Later, both the objects are immersed for a short and equal interval of time in a large tank of water, which is well agitated. The fractions of salt remaining in the cylinder and the sphere are X_C and X_S, respectively. Which of the following statements is correct?
a. $X_C > X_S$

b. $X_C = X_S$
c. $X_C < X_S$
d. X_C is greater/less than X_S depending on the length of the cylinder

66. In liquid-liquid extraction 10kg of a solution containing 2kg of solute C and 8 kg of solvent A is brought into contact with 10 kg of solvent B. Solvents A and B are completely immiscible in each other whereas solute C is soluble in both the solvents. The extraction process attains equilibrium. The equilibrium relationship between the two phases is $Y^* = 0.9X$ where Y^* is kg of C/kg of B and X is kg of C/kg of A. Choose the correct answer
a. the entire amount of C is transferred to solvent B
b. less than 2 kg but more than 1 kg of C is transferred to solvent B
c. less than 1 kg of C is transferred to B
d. no amount of C is transferred to B

67. At equilibrium, the concentration of water in vapor phase (C*) in kg/m^3 of air space and the amount of water (m) adsorbed per kg of dry silica gel are related by $C^* = 0.0667$ m. To maintain dry conditions in a room of air space 100 m^3 containing 2.2 kg of water vapour initially, 10 kg of dry silica gel is kept in the room. The fraction of initial water remaining in the air space after a long time (during which the temperature is maintained constant) is
a. 0.0
b. 0.2
c. 0.4
d. 1.0

68. A 25 cm × 25 cm × 1 cm flat sheet weighing 1.2 kg initially was dried from both sides under constant drying rate conditions. It took 1500 seconds for the weight of the sheet to reduce to 1.05 kg. Another 1 m × 1 m × 1 cm flat sheet of the same material is to be dried from one side only. Under the same constant drying rate conditions, the time required for drying (in seconds) from its initial weight of 19.2 kg to 17.6 kg is
a. 1000
b. 1500
c. 2000
d. 2500

69. A distillation column with N plates is being operated under normal conditions. At some point in time, the operation is shifted to total reflux condition (i.e., no product and residue are being withdrawn and feed to the column is stopped). At the new steady state,
a. composition of vapours and that of liquid do not vary throughout the column
b. reboiler load and condenser load are minimum
c. the top and bottom compositions are unchanged with and without total reflux
d. the top and bottom compositions correspond to the maximum enrichment achievable

70. An aqueous solution of methanol is to be distilled in a tray column. High pressure steam is available as a source of heat. For a given reflux ratio and overhead composition two options are being explored:
(i) a reboiler is used, and
(ii) no reboiler is used but steam is fed directly to the bottom of the column. As compared to option (i), in option (ii)
a. less number of trays are required
b. composition of the residue remains unchanged
c. more number of trays are required but the residue composition remains unchanged
d. more number of trays are required and the residue composition is more dilute in methanol

71. The following gas phase reaction is taking place in a plug flow reactor.

$$A + \frac{1}{2}B \rightarrow C$$

A stoichiometric mixture of A and B at 300 K is fed to the reactor. At I m along the length of the reactor, the temperature is 360K. The pressure drop is negligible and an ideal gas behavior can be assumed. Identify the correct expression relating the concentration of A at the inlet (C_{A0}), concentration of A at 1 m (C_A) and the corresponding conversion of A(X).

a. $C_A = 1.2C_{A0}\dfrac{(1-X)}{(1-0.33X)}$

b. $C_A = 1.2C_{A0}\dfrac{(1-X)}{(1-0.5X)}$

c. $C_A = 0.83 C_{A0} \dfrac{(1-X)}{(1-0.33X)}$

d. $C_A = 0.83 C_{A0} \dfrac{(1-X)}{(1-0.5X)}$

72. A second order liquid phase reaction A → B is carried out in a mixed flow reactor operated in semi-batch mode (no exit stream). The reactant A at concentration C_{AF} is fed to the reactor at a volumetric flow rate of F. The volume of the reacting mixture is V and the density of the liquid mixture is constant. The mass balance for A is

a. $\dfrac{d(VC_A)}{dt} = -F(C_{AF} - C_A) - kC_A^2 V$

b. $\dfrac{d(VC_A)}{dt} = F(C_{AF} - C_A) - kC_A^2 V$

c. $\dfrac{d(VC_A)}{dt} = -FC_A - kC_A^2 V$

d. $\dfrac{d(VC_A)}{dt} = FC_{AF} - kC_A^2 V$

73. For an isothermal second order aqueous phase reaction A → B, the ratio of the time required for 90% conversion to the time required for 45% conversion is

a. 2
b. 4
c. 11
d. 22

74. An isothermal aqueous phase reversible reaction P⇔P is to he carried out in a mixed flow reactor. The reaction rate in kmol/(m^3 h) is given by r = $0.5C_P - 0.125C_R$

A stream containing only P enters the reactor. The residence time required (in hours) for 40% conversion of P is

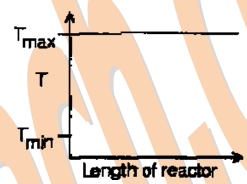
a. 0.80
b. 1.33
c. 1.60
d. 2.67

75. A pollutant P degrades according to first order kinetics. An aqueous stream containing P at 2 kmol/m^3 and volumetric flow rate 1 m^3/h requires a mixed flow reactor of volume V to bring down the pollutant level to 0.5 kmol/m^3. The inlet concentration of the pollutant is now doubled and the volumetric flow rate is tripled. If the pollutant level is to be brought down to the same level of 0.5 kmol/m^3, the volume of the mixed flow reactor should be increased by a factor of

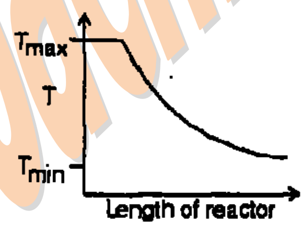
a. 7
b. 6
c. 3
d. 7/3

76. Consider a reversible exothermic reaction in a plug flow reactor. The maximum and minimum permissible temperatures are T_{max} and T_{min}, respectively. Which of the following temperature (T) profiles will require the shortest residence rime to achieve the desired conversion?

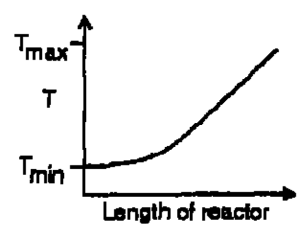
a.



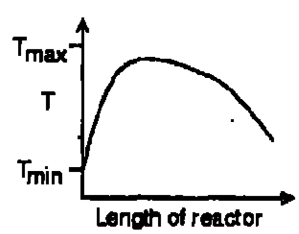
b.



c.



d.



77. An irreversible aqueous phase reaction A + B → P is carried out in an adiabatic mixed flow reactor. A feed containing 4 kmol/m^3 of each A and B enters the reactor at 8 m^3/h. If the temperature of the exit stream is never to exceed 390 K, what is the maximum feed inlet temperature allowed?

Data: Heat of reaction = –50 kJ/mol, density of the reacting mixture = 1000 kg/m^3, specific heat of reacting mixture = 2 kJ/kg K.

The above data can be assumed to be independent of composition and temperature.

a. 190
b. 290
c. 390
d. 490

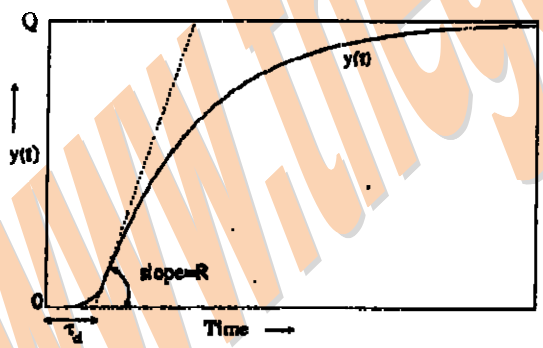
78. Match first order system given in Group I with the appropriate time constant in Group II.

Group I
A. Thermometer
B. Mixing

Group II
1. $(mC_p)/(hA)$
2. q/V
3. V/q
4. $(hA)/(mC_p)$

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

79. The experimental response of the controlled variable y(t) for a step change of magnitude P in the manipulated variable x(t) is shown below.



The appropriate transfer function of the process is

a. $\dfrac{(Q/P)e^{-(Q/R)s}}{\tau_d s+1}$

b. $\dfrac{(Q/R)e^{-\tau_d s}}{(Q/P)s+1}$

c. $\dfrac{(Q/P)e^{-\tau_d s}}{(Q/R)s+1}$

d. $\dfrac{(Q/R)e^{-(P/Q)s}}{\tau_d s+1}$

80. Consider a system with open loop transfer function

$$G(s)=\frac{1}{(s+1)(2s+1)(5s+1)}$$

Match the range of ω (frequency) in Group I with the slope of the asymptote of the log AR (amplitude ratio) versus log ω plot in Group II.

Group I
A. $0 < \omega < 0.2$
B. $\omega > 1$

Group II
1. –5
2. –3
3. –2
4. –1
5. zero

	A	B
a.	5	2
b.	4	2
c.	5	3
d.	4	1

81. The process and disturbance transfer functions for a system are given by

$$G_p(s)=\frac{\bar{y}(s)}{\bar{m}(s)}=\frac{2}{(2s+1)(5s+1)}$$

$$G_d(s)=\frac{\bar{y}(s)}{\bar{d}(s)}=\frac{1}{(2s+1)(5s+1)}$$

The feed forward controller transfer function that will keep the process output constant for changes in disturbance is

a. $\dfrac{2}{(2s+1)^2(5s+1)^2}$

b. $\dfrac{(2s+1)^2(5s+1)^2}{2}$

c. $\dfrac{1}{2}$

d. $(2s+1)(5s+1)$

82. For the block diagram shown below,

the characteristic equation is

a. $\tau_I s\left(\tau_p s+1\right)+K_c K_p\left(\tau_I s+1\right)e^{-\tau_d s}=0$

b. $\left(\tau_m s+1\right)\left(\tau_p s+1\right)+K_m K_p e^{-\tau_d s}=0$

c. $\tau_I s\left(\tau_p s+1\right)+K_c K_p\left(\tau_I s+1\right)e^{-\tau_d s}=0$

d. $\left(\tau_m s+1\right)\left(\tau_p s+1\right)+K_c K_p K_m e^{-\tau_d s}=0$

Common Data for Questions (83 & 84)

Fixed capital investment for a chemical plant is Rs 40 million with an estimated useful life of 6 years and a salvage value of Rs 4 million. The rate of interest is 15%. Tax is 25% of the annual taxable income. In the first year of operation, the income from sales is Rs 20 million and manufacturing expenses are Rs 5 million. The plant depreciates on a straight line basis.

83. The rate of return on investment is given by
 a. 50%
 b. 37.5%
 c. 32%
 d. 20%

84. The net present value (NPV) in million Rs at the start and at the end of the first year of operation is respectively given by
 a. zero and –28.9
 b. –40 and –28.9
 c. –40 and 12.75
 d. zero and 12.75

85. Pick the WRONG design guideline for a reactor fn which the reactions A $\rightarrow$ R (desired) and A $\rightarrow$ S(undesired) are to take place. The ratio of the reaction rates is $r_R/r_S = (k_1/k_2)\, C_A^{a-b}$.
 a. use high pressure and eliminate inerts when a > b
 b. avoid recycle when a > b
 c. use batch reactor or plug flow reactor when a > b
 d. use CSTR with a high conversion when a > b

86. Multiple effect evaporators are commonly used in the manufacture of
 A. Paper
 B. Super phosphate
 C. Sugar
 D. Fats
 a. A and B
 b. A and C
 c. A and D
 d. C and D

87. Match the process in Group I with the product in Group II

 Group I
 A. DCDA process
 B. Mercury Cell

 Group II
 1. Sodium hydroxide
 2. Sulfuric acid
 3. Sodium carbonate
 4. Nitric acid

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

88. Match the product in Group I with the raw materials in Group II

 Group I
 A. Urea
 B. Polyester

 Group II
 1. Ammonia and carbon dioxide
 2. Dimethyl terephthalate and ethylene glycol
 3. Ammonia and carbon monoxide
 4. Hexamethylene diamine and adipic
 5. acid

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

89. Match the product in Group I with the nature of the reaction in Group II

 Group I
 A. Polyethylene
 B. Nylon
 C. Polystyrene

 Group II
 1. Condensation polymerization
 2. Addition polymerization

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

90. Match the process in Group I with the catalyst used in Group II.

Group I

A. Sulfuric acid manufacture

B. Vegetable oil hydrogenation

Group II

1. Platinum
2. Vanadium pentoxide
3. Iron
4. Raney nickel

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