CHEMICAL ENGINEERING

ONE MARKS QUESTIONS (1-30)

1. A box contains 6 red balls and 4 green balls, one ball is randomly picked and then a second ball is picked without replacement of the first ball. The probability that both the balls are green is
   a. 1/15
   b. 2/25
   c. 2/15
   d. 4/25

2. The directional derivative of $f(x, y, z) = x^2+y^2+z^2$ at the point (1, 1, 1) in the direction $\underline{\mathbf{i}} - \underline{\mathbf{k}}$ is
   a. 0
   b. 1
   c. $\sqrt{2}$
   d. $2\sqrt{2}$

3. The Taylor series expansion of the function: $F(x) = x/(1 + x)$ around $x = 0$ is
   a. $x + x^2 + x^3 + x^4$..................
   b. $1 + x + x^2 + x^3 + x^4$..................
   c. $2x + 4x^2 + 8x^3 + 16x^4$..................
   d. $x - x^2 + x^3 - x^4$..................

4. For estimation of heat capacity of a solid compound, one can use
   a. Clapeyron's equation
   b. Gibb's equation
   c. Kopp's rule
   d. Trouton's rule

5. For organic compounds, Group Contribution Method can be used for estimation of
   a. critical properties
   b. specific gravity
   c. specific volume
   d. thermal conductivity

6. When dilute aqueous solutions of two salts are mixed, the process is associated with
   a. decrease in temperature
   b. increase in temperature
   c. no change in temperature
   d. change in temperature which is a function of composition

7. In Joule's experiments, an insulated container contains 20 kg of water initially at 25°C. It is stirred by an agitator, which is made to turn by a slowly falling body weighing 40 kg through a height of 4 m. The process is repeated 500 times. The acceleration due to gravity is 9.8 ms^{-2}. Neglecting the heat capacity of agitator, the temperature of water (in °C) is
   a. 40.5
   b. 34.4
   c. 26.8
   d. 75

8. One mole of Nitrogen at 8 bar and 600 K is contained in a piston-cylinder arrangement. It is brought to 1 bar isothermally against a resisting pressure of 1 bar. The work done (in Joules) by the gas is
   a. 30554
   b. 10373
   c. 4988.4
   d. 4364.9

9. For water at 300°C, it has a vapour pressure 8592.7 kPa and fugacity 6738.9 kPa. Under these conditions, one mole of water in liquid phase has a volume 25.28 cm^3, and that in vapour phase 391.1 cm^3. Fugacity of water (in kPa) at 9000 kPa will be
   a. 6738.9
   b. 6753.5
   c. 7058.3
   d. 9000

10. A lubricant 100 times more viscous than water would have a viscosity (in Pa-s)
   a. 0.01
   b. 0.1
   c. 1
   d. 10

11. The velocity profile for a Bingham plastic fluid flowing (under laminar conditions) in a pipe is

a. parabolic
b. flat
c. flat near the wall and parabolic in the middle
d. parabolic near the wall and flat in the middle

12. Energy requirement (per unit mass of material crushed/ground) is highest for
a. Jaw crusher
b. Rod mill
c. Ball mill
d. Fluid energy mill

13. Three solid objects of the same material and of equal mass - a sphere, a cylinder (length = diameter) and a cube - are at 500°C initially. These are dropped in a quenching bath containing a large volume of cooling oil each attaining the bath temperature eventually. The time required for 90% change of temperature is smallest for
a. cube
b. cylinder
c. sphere
d. equal for all the three

14. A dilute aqueous solution is to be concentrated in an evaporator system. High pressure steam is available. Multiple effect evaporator system is employed because
a. total heat transfer area of all the effects is less than that in a single effect evaporator system
b. total amount of vapour produced per kg of feed steam in a multieffect system is much higher than in a single effect
c. boiling point elevation in a single effect system is much higher than that in any effect in a multieffect system.
d. heat transfer coefficient ma single effect is much lower than that in any effect in a multieffect system

15. The units of resistance to heat transfer are
a. $Jm^{-2}K^{-1}$
b. $Jm^{-1}K^{-1}$
c. $Wm^{-2}K^{-1}$
d. $W^{-1}m^{2}K$

16. The diffusion coefficient, in m^2/s, of Acetic acid in Benzene (liquid in liquid) is
a. 2.09×10^{-4}
b. 2.09×10^{-5}
c. 2.09×10^{-9}
d. 2.09×10^{-12}

17. Component A is diffusing in a medium B. The flux NA relative to a stationary point is equal to the flux due to molecular diffusion if
a. mass transfer is accompanied by reaction
b. diffusion of A is in stagnant medium B
c. molecular mean free path is high
d. there is equimolar counter-diffusion

18. Minimum reflux ratio in a distillation column results in
a. optimum number of trays
b. minimum reboiler size
c. maximum condenser size
d. minimum number of trays

19. For a series of reactions $A \xrightarrow{k_1} B \xrightarrow{k_2} C$ having $k_1 << k_2$, the reaction system can be approximated as
a. $A \xrightarrow{k_1} B$
b. $A \xrightarrow{k_2} B$
c. $A \xrightarrow{k_1} C$
d. $A \xrightarrow{k_2} C$

20. An elementary liquid phase decomposition reaction $A \xrightarrow{k} 2B$ is to be carried out in a CSTR. The design equation is
a. $k\tau = X_A/(1-X_A)$
b. $k\tau = \dfrac{X_A(1+X_A)}{(1-X_A)}$
c. $k\tau = X_A/(1-X_A)^2$
d. $k\tau C_{A0} = \dfrac{X_A/(1+X_A)^2}{(1-X_A)^2}$

21. Find a mechanism that is consistent with the rate equation and reaction given below
$2A + B \rightarrow A_2B \quad (-r_A) = kC_AC_B$
a. $A + B \rightleftharpoons AB;\ AB + A \rightarrow A_2B$
b. $A + B \rightarrow AB;\ AB + A \rightarrow A_2B$
c. $A + A \rightarrow AA;\ AA + B \rightarrow A_2B$

d. $A + A \rightleftharpoons AA; AA + B \rightarrow A_2B$

22. Match the measured process variables with the list of measuring devices given below

List I (Measured process variables)

A. Temperature

B. Pressure

C. Flow

D. Liquid level

E. Composition

List II (Measuring devices)

1. Bourdon tube element
2. Orifice plates
3. Infrared analyzer
4. Displacer devices
5. Pyrometer

Codes;

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

23. Suppose that the gain, time constant, and dead time of a process with the following transfer function

$G_c(s) = 10 \exp(-0.1s)/(0.5s + 1)$

are known with a possible error of ± 20% of their values. The largest permissible gain K_c of a proportional controller needs to be calculated by taking the values of process gain, time constant and dead time as

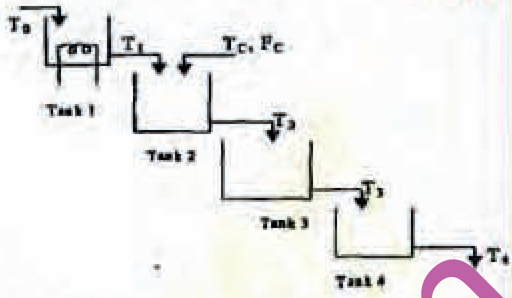
a. 8, 0.6, 0.08

b. 12, 0.6, 0.08

c. 8, 0.6, 0.12

d. 12, 0.4, 0.08

24. Water is flowing through a series of four tanks and getting heated as shown in figure. It is desired to design a cascade control scheme for controlling the temperature of water leaving the Tank 4 as there is a disturbance in the temperature of a second stream entering the Tank 2. Select the best place to take the secondary measurement for the secondary loop



a. Tank 1

b. Tank 2

c. Tank 3

d. Tank 4

25. Direct costs component of the fixed capital consists of

a. contingency

b. onsite and offsite costs

c. labour costs

d. raw material costs

26. A series of equal payments (e.g., deposit or cost) made at equal intervals of time known as

a. perpetuity

b. capital charge factor

c. annuity

d. future worth

27. The variables required to be known in correlations used for estimating the horse power of a centrifugal gas compressor and hence its cost are

1. inlet pressure
2. compressor RPM
3. delivery pressure
4. volumetric flow rate at inlet

a. 1, 2 and 3

b. 1 and 3

c. 3 and 4

d. 1, 3 and 4

28. 'Nylon 66' is so named because

a. the average degree of polymerization of the polymer is 1966

b. the number of carbon atoms between two nitrogen atoms are 6

c. the number of nitrogen atoms between two carbon atoms are 6

d. the polymer was first synthesized in 1966.

29. The catalytic converter for conversion of SO_2 to SO_3 by contact process should have feed with SO_2 content between

a. 2—5%
b. 7—10%
c. 12—15%
d. 20—25%

30. The composition of fresh feed to the high temperature high pressure urea autoclave

a. excess liquid ammonia and liquefied CO_2
b. excess liquid ammonia and compressed CO_2 gas
c. liquid ammonia and excess compressed CO_2
d. compressed NH_3 gas and excess compressed CO_2

TWO MARKS QUESTIONS (31-90)

31. The range of values for a constant 'K' to yield a stable system in the following set of time dependent differential equations is

$$\frac{dy_1}{dt} = -5y_1 + (4-K)y_2$$

$$\frac{dy_2}{dt} = y_1 - 2y_2$$

a. $0 < K < 7$
b. $6.25 < K < 10$
c. $-6 < K \le 6.25$
d. $0 \le K \le 7$

32. The value of y at $t \to \infty$ for the following differential equation for an initial value of $y(1) = 0$ is

$$(4t^2+1)\frac{dy}{dt} + 8yt - t = 0$$

a. 1
b. 1/2
c. 1/4
d. 1/8

33. The equilibrium data of component A in the two phases B and C are given below

X (moles of A/moles of B)	Y (moles of A/moles of C)
1	0.5
2	4.125

The estimate of Y for X = 4 by fitting a quadratic expression of a form $Y = mX^2$ for the above data is

a. 15.5
b. 16
c. 16.5
d. 17

34. A fluid element has a velocity $\underline{V} = -y^2x\underline{i} + 2yx^2\underline{j}$. The motion at $(x, y) = (1/\sqrt{2}, 1)$ is

a. rotational and incompressible
b. rotational and compressible
c. irrotational and compressible
d. irrotational and incompressible

35. The most general complex analytical-function $f(z) = u(x, y) + iv(x, y)$ for $u = x^2 - y^2$ is

a. z
b. [illegible]
c. [illegible]
d. $1/z^2$

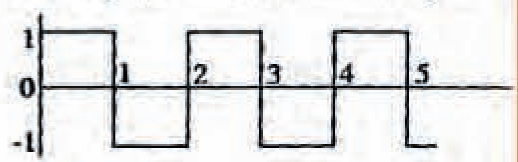
36. The differential equation

$$\frac{d^2x}{dt^2} + 10\frac{dx}{dt} + 25x = 0$$

will have a solution of the form (where C_1 and C_2 are constants)

a. $(C_1 + C_2t)e^{-5t}$
b. C_1e^{-2t}
c. $C_1e^{-5t}C_2e^{3t}$
d. $C_1e^{-5t} + C_2e^{2t}$

37. Find the Laplace transform of the following input function shown in Figure



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

b. $\frac{2(1-e^{-s})}{s}$

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

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

38. 6 g of carbon is burnt with an amount of air containing 18 g oxygen. The product contains 16.5 g CO_2 and 2.8 g CO besides other constituents. What is the degree conversion on the basis of disappearance of the limiting reactant?

a. 100%
b. 95%
c. 75%
d. 20%

39. An aqueous solution of 2.45% by weight H_2SO_4 has a specific gravity of 1.011. The composition expressed in normality is

a. 0.2500
b. 0.2528
c. 0.5000
d. 0.5055

40. Air at a temperature of 20°C and 750 mm Hg pressure has a relative humidity of 80%. What is its percentage humidity? Vapour pressure of water at 20°C is 17.5 mm Hg.

a. 80.38
b. 80
c. 79.62
d. 78.51

41. $Na_2SO_4.10\ H_2O$ crystals are formed by cooling 100 kg of 30% by weight aqueous solution of Na_2SO_4. The final concentration of the solute in the solution is 10%. The weight of crystals is.

a. [illegible]
b. 32.2
c. 4[illegible]5
d. 58.65

42. A sample of natural gas containing 80% Methane (CH_4) and the rest Nitrogen (N_2) is burnt with 20% excess air. With 80% of the combustibles producing CO_2 and the remainder going to CO the Orsat analysis in volume percent is

a. CO_2:6.26, CO:1.56, O_2:3.91, H_2O:15.66, N_2:72.60
b. CO_2:7.42, CO:1.86, O_2:4.64, N_2:86.02
c. CO_2:6.39, CO:1.60, O_2:3.99, H_2O:15.96, N_2:72.06
d. CO_2:7.60, CO:1.90, O_2:4.75, N_2:85.74

43. Heat capacity of air can be approximately expressed as $C_p = 26.693 + 7.365 \times 10^{-3}$ T where C_p is in J/(mol)(K) and T is in K. the heat given off by 1 mole of air when cooled at 1 atmospheric pressure from 500°C to – 100°C is

a. 10.73 kJ
b. 16.15 kJ
c. 18.11 kJ
d. 18.33 kJ

44. A solid metallic block weighing 5 kg has an initial temperature of [illegible]00°C; 40 kg of water initially at 25°C is contained in a perfectly insulated tank. The metallic block is brought into contact with water. Both of them come to equilibrium. Specific heat of block material is 0.[illegible] kJ kg^{-1} K^{-1}. Ignoring the effect of expansion and contraction, and also the heat capacity of tank, the total entropy change in kJ kg^{-1} K^{-1} is

a. -1.87
b. 0.0
c. 1.26
d. 3.91

45. The following heat engine produces power of 100,000 kW. The heat engine operates between 800 K and 300 K. it has a thermal efficiency equal to 50% of that of the Carnot engine for the same temperatures. The rate at which heat is absorbed from the hot reservoir is

a. 100,000 kW
b. 160,000 kW
c. 200,000 kW
d. 320,000 kW

46. A steam turbine operates with a superheated steam flowing at 1 kg s^{-1}. This steam is supplied at 41 bar and 500°C, and discharges at 1.01325 bar and 100°C

Data: 41 bar, 500°C

Enthalpy: 3443.9 kJ kg^{-1}

Entropy: 7.0785 kJ $kg^{-1}K^{-1}$

41 bar, 251.8 °C

Enthalpy of saturated steam: 2799.9kJ kg^{-1}

Entropy of saturated steam: 6.0583kJ$kg^{-1}K^{-1}$

1.01325 bar 100°C

Enthalpy of saturated vapour: 2676 kJ kg^{-1}
Enthalpy of saturated liquid: 419.1 kJ kg^{-1}
Entropy of saturated vapour: 7.3554 kJ kg^{-1} K^{-1}
Entropy of saturated liquid: 1.3069 kJ kg^{-1} K^{-1}
The maximum power output (in kW) will be

a. 644.0
b. 767.9
c. 871.3
d. 3024.8

47. At 60°C, vapour pressures of methanol and water are 84.562 kPa and 19.953 kPa respectively. An aqueous solution of methanol at 60°C exerts a pressure of 39.223 kPa; the liquid phase and vapour phase mole fractions of methanol are 0.1686 and 0.5714 respectively. Activity coefficient of methanol is

a. 1.572
b. 1.9398
c. 3.389
d. 4.238

Q. 48 – 49 are based on the data supplied in the paragraph below

One kg of saturated steam at 100°C and 1.0132 bar is contained in a rigid walled vessel. It has a volume 1.673 m^3. It cools to 98°C, the saturation pressure is 0.943 bar; one kg of water vapour under these conditions has a volume of 1.789 m^3

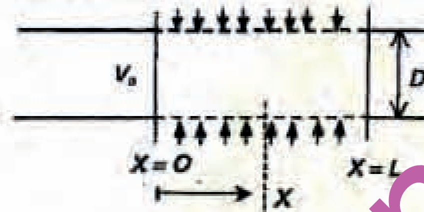
48. The amount of water vapour condensed (in kg) is

a. 0.0
b. 0.065
c. 0.1
d. 1.0

49. The latent heat of condensation (kJ kg^{-1}) under these conditions is

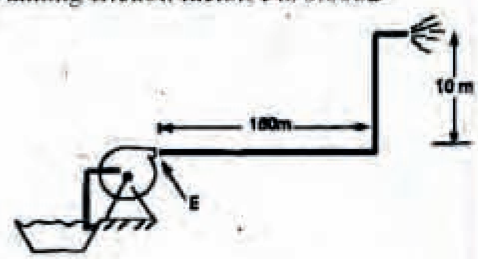
a. 40732
b. 2676
c. 2263
d. 540

50. A pipe has a porous section of length L as shown in the figure. Velocity at the start of this section is V_o. If fluid leaks into the pipe through the porous section at a volumetric rate per unit area $q(x/L)^2$, what will be the axial velocity in the pipe at any x? Assume incompressible one-dimensional flow i.e., no gradients in the radial direction



a. $V_x = V_o + q\frac{x^3}{L^2 D}$
b. $V_x = V_o + \frac{1}{3}q\frac{x^3}{L^2}$
c. $V_x = V_o + 2q\frac{x^2}{LD}$
d. $V_x = V_o + \frac{4}{3}q\frac{x^3}{L^2 D}$

51. A centrifugal pump is used to pump water through a horizontal distance of 150 m and then raised to an overhead tank 10 m above. The pipe is smooth with an I.D. of 50 mm. What head (m of water) must the pump generate at its exit (E) to deliver water at a flow rate of 0.001 m^3/s? The Fanning friction factor, f is 0.0062



a. 10 m
b. 11 m
c. 12 m
d. 20 m

52. Match the following dimensionless numbers with the appropriate ratio of forces

List I (Dimensionless Number)
A. Froude Number
B. Reynolds Number
C. Friction factor
D. Nusselt Number

List II (Ratio of forces)
1. Shear force / inertial force

2. Convective heat transfer / conductive heat transfer
3. Gravitational force / viscous force
4. Inertial force / viscous force
5. Inertial force / gravitational force

Codes

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

Q. 53 - 54 are based on the data supplied in the paragraph below

A bed of spherical particles (sp. gravity 2.5) of uniform size 1500 µm is 0.5 m in diameter and 0.5 m high. In the packed bed state, the porosity may be taken as 0.4. Ergun's equation for the above particle-fluid system (in SI units) is given below

$\Delta P / L = 375 \times 10^5 V_{OM} + 10.94 \times 10^6 V_{OM}^2$ (SI Units)

53. If water is to be used as the fluidizing medium, the minimum fluidization velocity, V_{OM} is
a. 12 mm/s
b. 16 mm/s
c. 24 mm/s
d. 28 mm/s

54. In actual operation, the above bed has a height = 1m. What is the porosity of the fluidized bed?
a. 0.2
b. 0.5
c. 0.7
d. 0.[illegible]

55. The basic filtration equation is given as
$$\frac{dt}{dV} = \frac{\mu}{A\Delta P}\left(\frac{\alpha C V}{A} + R_m\right)$$
where V is volume of the filtrate; A is the filtration area; a is specific cake resistance; µ is viscosity of the filtrate, and C is the concentration of solids in the feed slurry
In a 20 min. constant rate filtration, 5 m^3 of filtrate was obtained. If this is followed by a constant pressure filtration, how much more time in minutes will it take for another 5 m^3 of filtrate to be produced? Neglect filter medium resistance, R_m; assume incompressible cake
a. 10
b. 20
c. 25
d. 30

56. A process stream of dilute aqueous solution flowing at the rate of 10 kg s^{-1} is to be heated. Steam condensate at 95°C is available for heating purposes also at a rate of 10 kg s^{-1}. A 1 - 1 shell and tube heat exchanger is available. The best arrangement is
a. counterflow with process stream on shell side
b. counterflow with process stream on tube side
c. parallel flow with process stream on shell side
d. parallel flow with process stream on tube side

57. The inner wall of a furnace is at a temperature of 700°C. The composite wall is made of two substances, 10 and 20 cm thick with thermal conductivities of 0.05 and 0.1 $Wm^{-1}{}^{\circ}C^{-1}$ respectively. The ambient air is at 30°C and the heat transfer coefficient between the outer surface of wall and air is 20 W m^{-2} °C^{-1}. The rate of heat loss from the outer surface in W m^2 is
a. 165.4
b. 167.5
c. 172.8
d. 175

58. Steam is to be condensed in a shell and tube heat exchanger; 5 m long with a shell diameter of 1 m. Cooling water is to be used for removing the heat. Heat transfer coefficient for the cooling water, whether on shell side or tube side, is same. The best arrangement is
a. vertical heat exchanger with steam on tube side
b. vertical heat exchanger with steam on shell side
c. horizontal heat exchanger with steam on tube side
d. horizontal heat exchanger with steam on shell side

59. A fluid is flowing inside the inner tube of a double pipe heat exchanger with diameter 'd'. For a fixed mass flow rate, the tube side heat transfer coefficient for turbulent flow conditions is proportional to

a. $d^{0.8}$

b. $d^{-0.2}$

c. d^{-1}

d. $d^{-1.8}$

60. Air is to be heated by condensing steam. Two heat exchangers are available: (i) a shell and tube heat exchanger, and (ii) a finned tube heat exchanger. Tube side heat transfer area is equal in both cases. The recommended arrangement is

a. finned tube heat exchanger with air inside and steam outside

b. finned tube heat exchanger with air outside and steam inside

c. shell and tube heat exchanger with air inside tubes and steam shell side

d. shell and tube heat exchanger with air on shell side and steam inside tubes

61. For a given ambient air temperature with increase in the thickness of insulation of a hot cylindrical pipe, the rate of heat loss from the surface would

a. decrease

b. increase

c. first decrease and then increase

d. first increase and then decrease

62. Experiments were conducted to determine the flux of a species from a stagnant medium across a gas-liquid interface. The overall mass transfer coefficient based on the liquid side for dilute systems for the above was estimated to be 4×10^{-3} kg mol/m^2s. The equilibrium data for the system is given as $y = 2x$. The flux across the interface (in kg mol/m^2s) for bulk concentrations of A in gas phase and liquid phase as $y = 0.4$ and $x = 0.01$, respectively is

a. 3.6×10^{-4}

b. 8.5×10^{-4}

c. 5.6×10^{-3}

d. 8.5×10^{-3}

63. H_2S is being absorbed in a gas absorber unit. The height of the transfer unit based on the overall mass transfer coefficient on the gas side is 0.4 m. The equilibrium data given by $y = 1.5x$. The bulk concentration of H_2S has to be reduced from 0.05 to 0.001 mole fraction in the gas side. The height of the tower (in meters) corresponding to an operating line given by $y = 5x + 0.001$ is

a. 2.0

b. 1.56

c. 1.0

d. 0.56

64. The Reynolds Number of the liquid was increased 100 fold for a laminar falling film used for gas-liquid contacting. Assuming penetration theory is applicable, the fold-increase in the mass transfer coefficient (k_C) for the same system is

a. 100

b. 10

c. 5

d. [illegible]

65. A pure drug is administered as a sphere and as a cube. The amount of drug is the same in the two tablets. Assuming that the shape and size do not influence the mass transfer, the ratio of rate of dissolution in water at $\tau = 0$ for the cubic to spherical tablet is

a. 0.54

b. 1.04

c. 1.24

d. 1.94

66. A solid is being dried in the linear drying rate regime from moisture content X_0 to X_F. The drying rate is zero at $X = 0$ and the critical moisture content is the same as the initial moisture, X_0. The drying time for $M = L_S/AR_C$ is

(where L_S: total mass of dry solids, A: total surface area for drying, R_C: constant maximum drying rate per unit area, and X: moisture content (in mass of water/mass of dry solids)

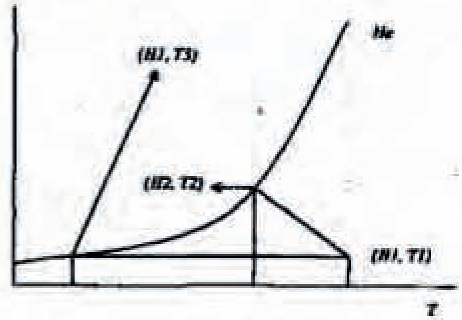
a. $M(X_0 - X_F)$

b. $M(X_0 / X_F)$

c. $M \ln(X_0 / X_F)$

d. $MX_0 \ln(X_0 / X_F)$

67. The following plot gives the saturated humidity (He) versus Temperature (T)



Line joining (H1, T1) and (H2, T2) is the constant enthalpy line. Choose the correct one from among the alternatives A, B, C and D

a. T1 – Dew Point Temp.; T2 – Dry Bulb Temp.; T3 – Wet Bulb Temp.
b. T1 – Dew Point Temp.; T2 – Wet Bulb Temp.; T3 – Dry Bulb Temp.
c. T1 – Wet Bulb Temp.; T2 – Dry Bulb Temp.; T3 – Dew Point Temp.
d. T1 – Dry Bulb Temp.; T2 – Wet Bulb Temp.; T3 – Dew Point Temp.

68. Compound A is extracted from a solution of A + B into a pure solvent S. A co-current unit is used for the liquid-liquid extraction. The inlet rate of the solution containing A is 200 moles of B/hr m^2 and the solvent flow rate is 400 moles of S/hr m^2. The equilibrium data is represented by $Y = 3X^2$ where Y is in moles of A/moles of B and X is in moles of A/moles of S. The maximum percentage extraction achieved in the unit is

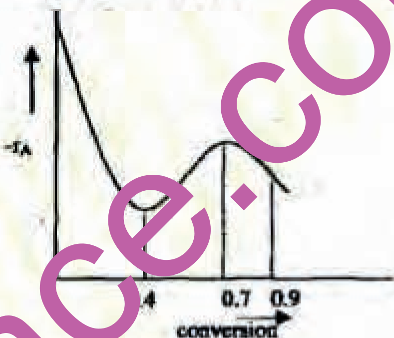
a. 25%
b. 50%
c. 70%
d. 90%

69. A CSTR is to be designed in which an exothermic liquid phase first order reaction of the type A → R is taking place. The reactor is to be provided with a jacket in which coolant is flowing. Following data is given

C_{A0} = 5 kmol/m^3 X_A = 0.5; feed temperature = reactor temperature = 40°C; rate constant at 40°C = 1 min^{-1}; (ΔH) = -40 kJ/mol; ρ = 1000 kg/m^3 C_p = 4 J/gm°C; q = 10^{-3} m^3/min (ρ and C_p are same for the reactant and product streams). The amount of heat to be removed is

a. 2/3 kW
b. 1 kW
c. 5/3kw
d. 4 kW

70. A liquid phase reaction is to be carried out under isothermal conditions. The reaction rate as a function of conversion has been determined experimentally and is shown in Figure given below. What choice of reactor or combination of reactors will require the minimum overall reactor volume, if a conversion of 0.9 is desired?



a. CSTR followed by a PFR
b. PFR followed by a CSTR
c. CSTR followed by a PFR followed by CSTR.
d. PFR followed by a CSTR followed by a PFR

Q. 71—72 are based on the data supplied in the paragraph below

The following gas phase reactions are carried out isothermally in a CSTR

$A \rightarrow 2R \quad r_1 = k_1 p_A \quad k_1 = 20 mol/(\sec\, m^3 bar)$

$A \rightarrow 3S \quad r_2 = k_2 p_A \quad k_2 = 40 mol/(\sec\, m^3 bar)$

total pressure = 1 bar, F_{A0} = 1 mol/sec, feed is pure A

71. What is the maximum possible value of FR (mol/sec)?

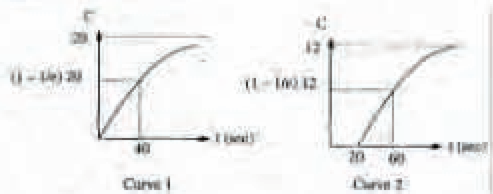
a. 1/3
b. 1/2
c. 2/3
d. 2

72. The volume of a CSTR required for a fractional conversion of A equal to 0.3 due to the first reaction is

a. 0.011

b. 0.21
c. 0.275
d. 0.375

73. A step input tracer test is used to explore the flow pattern of fluid through a vessel of total volume equal to 1 m^3 having a feed rate of 1 m^3/min.



Identify for each curve in Group 1 a suitable flow model from the list given under Group 2

Group 1
A. Curve 1
B. Curve 2

Group 2
1. PFR and CSTR in series
2. CSTR with dead space
3. PFR in series with a CSTR and dead space
4. CSTR

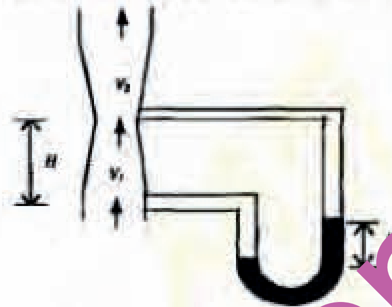
a. A-4, B-3
b. A-4, B-1
c. A-2, B-3
d. A-2, B-1

74. Following isothermal kinetic data are obtained in a basket type of mixed flow reactor for a porous catalyst. Determine the role of pore diffusion and external mass transfer processes

Pellet diameter	Leaving concentration of the reactant	Spinning rate of basket	$(-r'_A)$
[illegible]	1	high	2
[illegible]	1	low	1
[illegible]	1	high	1

a. Strong pore diffusion control and mass transfer not controlling
b. Both pore diffusion and mass transfer not controlling
c. Both pore diffusion and mass transfer controlling
d. Mass transfer controlling

75. The pressure differential across a vertical venturimeter (shown in Figure) is measured with the help of a mercury manometer to estimate flow rate of water flowing through it. The expression for the velocity of water at the throat is



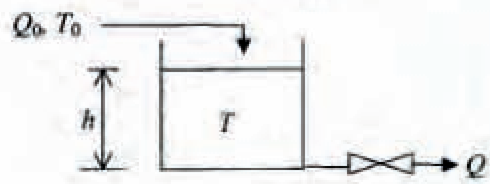
a. $\frac{V_2^2 - V_1^2}{2g} = h\rho_m / \rho_f$

b. $\frac{V_2^2 - V_1^2}{2g} = h(\rho_m - \rho_w) / \rho_f$

c. $\frac{V_2^2 - V_1^2}{2g} + H = h(\rho_m - \rho_w) / \rho_f$

d. $\frac{V_2^2 - V_1^2}{2g} = h(\rho_m - \rho_w) / \rho_f$

76. Water is entering a storage tank at a temperature T_0 and flow rate Q_0 and leaving at a flow rate Q and temperature T. There are negligible heat losses in the tank. The area of cross section of the tank is A_c. The model that describes the dynamic variation of water temperature in the tank with time is given as



a. $Q_0(T_0 - T) = A_c h \frac{dT}{dt}$

b. $Q_0 T_0 - QT = A_c h \frac{dT}{dt}$

c. $Q(T_0 - T) = A_c h \frac{dT}{dt}$

d. $Q(T_0 - T) = A_c \frac{d(Th)}{dt}$

77. Find the ultimate gun and frequency for a proportional controller in the case of a process having the following transfer function

$$G_p(s) = \frac{1}{(4s+1)(2s+1)(s+1)}$$

a. $\omega = \frac{1}{\sqrt{14}}; K_c = \frac{45}{7\sqrt{14}}$

b. $\omega = \sqrt{\frac{7}{6}}; K_c = \frac{46}{3}$

c. $\omega = 1; K_c = 13$

d. $\omega = \sqrt{\frac{7}{8}}; K_c = \frac{45}{4}$

78. Match the type of controller given in Group 2 that is most suitable for each application given in Group 1

Group 1

A. Distillation column bottoms level to be controlled with bottoms flow

B. Distillation column pressure to be controlled by manipulating vapor flow from the top plate

C. Flow control of a liquid from a pump by positioning the valve in the line

D. Control of temperature of a CSTR with coolant flow in the jacket

Group 2

1. P control
2. P-I control
3. P-I-D control

Codes

	A	B	C	D
a.	1	1	2	3
b.	2	2	3	3
c.	2	2	[illegible]	1
d.	2	3	2	3

79. In the case of a feed forward control scheme, which of the following is NOT true?

1. It is insensitive to modeling errors
2. Cannot cope with unmeasured disturbances
3. It waits until the effect of the disturbance has been felt by the system before control action is taken
4. Requires good knowledge of the process model
5. Requires identification of all possible disturbances and their direct measurement

a. 1 and 3

b. 1 and 4

c. 2 and 5

d. 3 and 4

80. Temperature control of an exothermic chemical reaction taking place in a CSTR is done with the help of cooling water flowing in a jacket around the reactor. The type of valve and controller action to be recommended are

a. air to open valve with the controller direct acting

b. air to close valve with the controller indirect acting

c. air to open valve with the controller indirect acting

d. air to close valve with the controller direct acting

81. Two pumps under consideration, for installation in a plant have the following capital investments and salvage values. Pump A: C_I = Rs. 40,000, C_{sal} = Rs. 3,900. Pump B: C_I = Rs. 50,000, C_{sal} = Rs. 2[illegible]. Using capitalized cost, determine what should be the common life of the pumps for both to be competitive (economically equivalent). Interest rate is 10% per annum. Maintenance and operational costs are negligible

a. 3 years

b. 5 years

c. 6 years

d. 8 years

Q. 82—83 are based on the data supplied in the paragraph below

A process has fixed capital investment of Rs. 150 lakhs, working capital Rs. 30 lakhs and salvage value zero. Annual revenues from sales are Rs. 250 lakhs, manufacturing costs 145 lakhs and other expenses 10% of the revenue. Assume project life span of 11 years, tax life of 5 years and interest rate to be 10 %. Tax rate is 40 % and straight line depreciation, i.e. 20% per year, is applicable

82. Discounted value (to present time) of the profit before tax (for the total plant life period) in rupees is

a. 228 lakhs

b. 400 lakhs

c. 520 lakhs

d. 660 lakhs

83. Discounted value of the depreciation benefit over the tax life in rupees is

a. 12 lakhs
b. 24 laths
c. 46 lakhs
d. 60 lakhs

84. In distillation column sizing calculations by short cut methods, match the following

A. Underwood's Equation
B. Fenske's Equation
C. Gilliland's Equation
D. Vapour velocity at flooding

1. Number of real trays
2. Column diameter
3. Minimum number of ideal trays
4. Actual number of ideal trays
5. Minimum reflux ratio
6. Tray efficiency

Codes:

	A	B	C	D
a.	1	3	4	6
b.	2	5	1	3
c.	5	3	6	2
d.	5	3	4	2

85. Identify the group in which all the polymers mentioned can be used to make fibers

a. Butadiene copolymers, Polyamides, Urea aldehydes
b. Cellulose derivatives, Polyisoprene, Polyethylene
c. Cellulose derivatives, Polyamides, Polyurethanes
d. Polypropylenes, Polyvinylchloride, Silicones

86. The preferred reacting system for oxidation of o-xylene to phthalic anhydride is

a. jacketed liquid phase CSTR
b. jacketed steam heated multitubular reactor
c. multitubular reactor with cooling
d. multistage multitubular reactor with interstage cooling

Q. 87—88 match the Items in Group I with the Items in Group 2

87. Match the Groups

Group 1

A. Calcium ammonium nitrate
B. $CaCl_2$ - NaCl liquor

Group 2

1. Fertilizer industry
2. Paper and Pulp industry
3. Soda ash industry

Codes;

	A	B
a.	1	3
b.	1	2
c.	3	1
d.	2	[illegible]

88. Match the Groups

Group 1

A. Black liquor
B. Activated silica alumina
C. Press mud

Group 2

1. Petroleum refining
2. Sugar factory

Codes

a. A – 1, C – 2
b. A – 2, B – 1
c. B – 1, C – 2
d. B – 2, C - 1

89. In a refinery, petroleum crude is fractionated into gas fraction, light ends, intermediate distillates, heavy distillates, residues and by products. The group of products including gas oil, diesel oil and heavy fuel oil belongs to the fraction

a. heavy distillates
b. intermediate distillates
c. light ends
d. residues

90. The order of preference for feedstock to a catalytic reformer is

a. catalytic naphtha - coking naphtha - virgin naphtha
b. coking naphtha - virgin naphtha - catalytic naphtha
c. virgin naphtha - catalytic naphtha - coking naphtha
d. virgin naphtha - coking naphtha - catalytic naphtha