

PART III

12 - CHEMICAL ENGINEERING

(Answer ALL questions)

56. A suspension of uniform particles in water at a concentration of 500 kg of solids per cubic meter of slurry is settling in a tank. Density of the particles is 2500 kg/m^3 and terminal velocity of a single particle is 20 cm/s . What will be the settling velocity of suspension? Richardson and Zaki index is 4.6.
- 20 cm/s ,
 - 14.3 cm/s ,
 - 7.16 cm/s ,
 - 3.58 cm/s ,
57. Bed pressure drop in an air fluidized bed of catalyst particles ($P = 2000 \text{ kg/m}^3$, $D_p = 0.05 \text{ cm}$) of 60 cm bed depth and bed porosity of 0.5 expressed in cm of water (manometer) is
- 90
 - 60
 - 45
 - 30
58. A pitot tube indicates 5 cm of water (manometer) when it is being used for measuring velocity of air. The velocity of air in m/s is -
- 5
 - 14.1
 - 56.22
 - 28.2
59. Tooth paste is an example of _____ fluid.
- Newtonian
 - Power law
 - Bingham plastic
 - Pseudo plastic
60. For the fluid ($\rho = 780 \text{ Kg/m}^3$; $\mu = 10 \text{ Kg/ms}$) rotating at 60 rpm in 2 m diameter cylinder, the Reynolds number is _____
- 9360
 - 156
 - 312
 - Data insufficient
61. The area of opening in any one screen in the series is exactly _____ that of opening in the next smaller screen.
- equal to
 - twice
 - Thrice
 - 4 times
62. The sphericity of a cylinder of 1 mm diameter and length 3 mm is :
- 0.9
 - 0.79
 - 0.6
 - 0.5
63. Size reduction does not occur due to compression in
- rod mills
 - gyratory crushers
 - jaw crushers
 - smooth crushers
64. Flow of filtrate through cake deposited on septum is usually laminar, which equation will you use to calculate the pressure drop for this situation
- Leva's equation
 - Kozeny-Carman equation
 - Blake-Plummer equation
 - Bernoulli's equation

65. Governing of a turbine means
- the head is kept constant under all conditions of working
 - the speed is kept constant under all conditions
 - the discharge is kept constant under all conditions
 - None of the above
66. Calculate the heat to be transferred to a liquid stream of ethanol at its normal boiling point to generate 100 Kg/h of saturated ethanol vapor. (Latent heat of vaporization of ethanol = 843 KJ/Kg).
- 23.38 KJ/s
 - 24 KJ/s
 - 23.83 KJ/s
 - data insufficiency
67. Specific gravity on API scale is given by the relation (G = specific gravity at 15.55°C)
- $API = 200 (G - 1)$
 - $API = (141.5/G) - 131.5$
 - $API = (140/G) - 130$
 - $API = 145 - (145/G)$
68. The Theoretical Oxygen demand for a simple reaction is 100 kmol. What is the amount of Nitrogen is flowing along with the Oxygen approximately?
- 375 kmol
 - 400 kmol
 - 100 kmol
 - 100 mol
69. What is the Valence for Calcium in Calcium Carbonate ($CaCO_3$)?
- 3
 - 1
 - $\frac{3}{2}$
 - 2
70. A mixture of toluene (40%) and benzene (60%) is fed to the Distillation column; recovery of benzene is 20% at the top, find the ratio of flow rate of benzene from Distillate to the bottoms. (Based on 1000 Kg of feed)
- 0.6
 - 0.2
 - 0.25
 - 0.4
71. Law of conservation of mass is FALSE for
- System involving reaction
 - Radioactive isotopes
 - Both (a) and (b)
 - None of the above
72. Match the technologies in Group 1 with the entries in Group 2:
- | Group 1 | | Group 2 | |
|-------------------------------------|---------------------------------------|---------|--|
| (P) Urea manufacture | (I) Microen-capsulation | | |
| (Q) Coal gasification | (II) Ultra-low sulphur diesel | | |
| (R) Controlled release of chemicals | (III) Shale oil | | |
| (S) Deep hydrodesulphurization | (IV) Prilling tower | | |
| | (V) Gas hydrates | | |
| | (VI) Gas-solid non-catalytic reaction | | |
- P - I, Q - V, R - II, S - VI
 - P - IV, Q - VI, R - I, S - II
 - P - IV, Q - I, R - III, S - II
 - P - V, Q - VI, R - IV, S - II
73. Styrene-Butadiene rubber is commercially manufactured by :
- Bulk polymerisation,
 - Suspension polymerisation,
 - Solution polymerisation,
 - Emulsion polymerisation

74. Phthalic anhydride is produced by the oxidation of,
- Naphthalene
 - Benzene
 - Toluene
 - Aniline

75. In Kraft pulping, fibrous material is cooked in the solution of
- sodium hydroxide and sodium carbonate
 - sodium hydroxide and sodium sulphide
 - sodium carbonate and sodium sulphate
 - sodium hydroxide and sodium chloride

76. A heat engine operates at 75% of the maximum possible efficiency. The ratio of the heat source temperature (in kelvin) to the heat sink temperature (in kelvin) is 5/3. The fraction of the heat supplied that is converted to work is

- 0.2
- 0.3
- 0.4
- 0.6

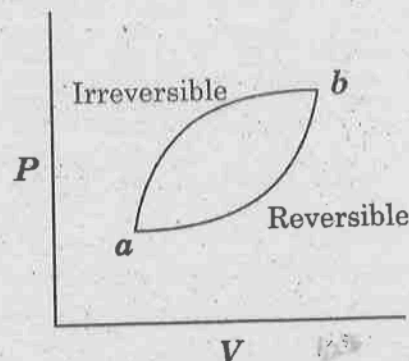
77. Air enters an adiabatic compressor at 300 K, the exit temperature for a compression ratio of 3, assuming air to be an ideal gas ($\gamma = C_p/C_v = 7/5$) and the process to be reversible, is

- $300 (3^{2/7})$
- $300 (3^{3/5})$
- $300 (3^{3/7})$
- $300 (3^{5/7})$

78. For a Carnot refrigerator operating between 40°C and 25°C, the coefficient of performance is

- 1
- 1.67
- 19.88
- 39.74

79. For the two paths as shown in the figure, one reversible and one irreversible, to change the state of the system from *a* to *b*



- $\Delta U, Q, W$ are the same
- ΔU is the same
- Q, W are the same
- $\Delta U, Q$ are different

80. Match the following.

Group I

Group II

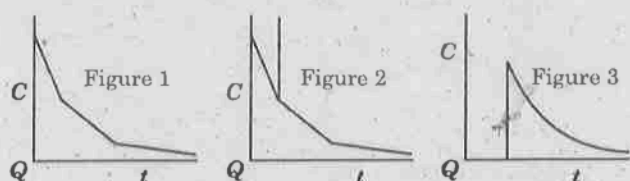
- | | |
|--------------------|-------------------|
| A. Heat | 1. State function |
| B. Internal energy | 2. Path function |
| C. Work | |
| D. Entropy | |

- A-2, B-1, C-1, D-1
- A-2, B-1, C-2, D-2
- A-2, B-2, C-1, D-1
- A-2, B-1, C-2, D-1

81. The gas phase reaction $A \rightarrow B + C$ is carried out in an ideal PFR achieving 40% conversion of A. The feed has 70 mol% A and 30 mol% inerts. The inlet temperature is 300 K and the outlet temperature is 400 K. The ratio of the outlet to inlet molar concentration of A (assuming ideal gas mixture and constant pressure) is

- 0.60
- 0.30
- 0.47
- 0.35

82. The following figures show the outlet tracer concentration profiles (cvst) for a pulse input.



Match the figures in Group I with the reactor configuration in Group II.

Group I

Group II

- P. Figure 1 I. PFR
Q. Figure 2 II. CSTR
R. Figure 3 III. PFR and CSTR in series
IV. PFR and CSTR in parallel
- a. P-II, Q-IV, R-III
b. P-IV, Q-III, R-I
c. P-III, Q-IV, R-II
d. P-I, Q-III, R-II

83. The reaction $A \rightarrow B$ is conducted in an adiabatic Plug Flow Reactor (PFR). Pure A at a concentration of 2 kmol/m^3 is fed to the reactor at the rate of $0.01 \text{ m}^3/\text{s}$ and at a temperature of 500 K . If the exit conversion is 20%, then the exit temperature (in kelvin) is

- a. 400
b. 500
c. 600
d. 1000

Given, Heat of reaction at $298 \text{ K} = -50000 \text{ kJ/kmol}$ of A reacted. Heat capacities, $C_{PA} = C_{PB} = 100 \text{ kJ/kmol-K}$ (may be assumed to be independent of temperature).

84. The first order series reaction $A \xrightarrow{k_1} B \xrightarrow{k_2} C$ is in a batch reactor. The initial concentrations of A, B and C (C_{A0} , C_{B0} , C_{C0} respectively) are all non-zero. The variation of C_B with reaction time will not show a maximum, if

- a. $k_2 C_B > k_1 C_A$
b. $k_1 C_A > k_2 C_B$
c. $C_{B0} > C_{A0}$
d. $C_{A0} > C_{B0}$

85. A pulse tracer is introduced in an ideal CSTR (with a mean residence time τ) at time $= 0$. The time taken for the exit concentration of the tracer to reach half of its initial value will be

- a. 2τ
b. 0.5τ
c. $\frac{\tau}{0.693}$
d. 0.693τ

86. Three solid objects of the same material and of equal masses—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

87. During the transient convective cooling of a solid object, Biot number $= 0$ indicates

- a. uniform temperature throughout the object
b. negligible convection at the surface of the object
c. significant thermal resistance within the object
d. significant temperature gradient within the object

88. For turbulent flow in a tube, the heat transfer coefficient is obtained from the Dittus-Boelter equation. If the tube diameter is halved and the flow rate is doubled, then the heat transfer coefficient will change by a factor of

- a. 1
b. 1.74
c. 6.1
d. 37

89. A composite flat wall of a furnace is made of two materials A and B. The thermal conductivity of A is twice of that of material B, while the thickness of layer of A is half of that of B. If the temperatures at the two sides of the wall are 400 K and 1200 K, then the temperature drop (in kelvin) across the layer of material A is
- 125
 - 133
 - 150
 - 160
90. According to the Fenske Equation what will be the minimum number of plates required in a distillation to separate an equimolar binary mixture of components A and B into an overhead fraction of containing 99 mol% A and a bottom fraction containing 98 mol% B? [Assume that the relative volatile ($\alpha_{AB} = 2$) does not change appreciably in the column].
- 5
 - 9
 - 12
 - 28
91. If q is defined as a moles of liquid flow in the stripping section of distillation column per moles of feed introduction, then saturated liquid feed
- $q > 1$
 - $q < 1$
 - $q = 1$
 - $q = 0$
92. For an ideal binary mixture of propane and butane, the mole fraction of propane in vapour phase in equilibrium with a liquid solution containing 50 mol% propane at a pressure of 101.3 kPa are 0.845 and y respectively where
- $y = 0.845$
 - $y < 0.845$
 - $y > 0.845$
 - $y \geq 0.845$
93. For mass transfer of a solute A present in a dilute mixture of A and B, the term PBM tends to
- total pressure p
 - zero
 - one
 - infinity
94. Which of the following analogies gives $S_i = f/2$?
- Reynolds analogy
 - Prandtl analogy
 - Chilton-Colburn analogy
 - None of the above
95. For a certain mass transfer process, $k_t = 1 \times 10^{-3}$ cm/s and $D_{AB} = 1 \times 10^{-5}$ cm²/s. The film thickness in cm is then
- 0.1
 - 0.01
 - 0.001
 - more information will be required for calculation of film thickness.
96. An operator was told to control the temperature of a reactor at 60°C. The operator sets the set-point of the temperature controller at 60. The scale actually indicated 0 to 100% of a temperature range of 0 to 200°C. This caused a runaway reaction by over pressurizing the vessel, which resulted in injury to the operator. The actual set-point temperature was
- 200°C
 - 60°C
 - 120°C
 - 100°C
97. The unit step response of a first order system with time constant τ and steady state gain K_p is given by
- $K_p (1 - e^{-t/\tau})$
 - $K_p (1 + e^{-t/\tau})$
 - $K_p (1 - e^{-2t/\tau})$
 - $K_p e^{-t/\tau}$

98. An example of an open-loop second order under-damped system is
- Liquid level in a tank
 - U-tube manometer
 - Thermocouple in a thermo-well
 - Two non-interacting first order system in series
99. Cascade control comes under the control configuration which uses
- one measurement and one manipulated variables
 - more than one measurement and one manipulated variables
 - one measurement and more than one manipulated variables
 - more than one measurement and more than one manipulated variables
100. 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 $\pm 20\%$ 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
- 8, 0.6, 0.08
 - 12, 0.6, 0.12
 - 8, 0.6, 0.12
 - 12, 0.4, 0.08
101. The unit step response of the transfer function $2s - 1/(3s + 1)(4s + 1)$ reaches its final steady state asymptotically after
- a monotonic increases
 - a monotonic decrease
 - initially increases and then decrease
 - initially decrease and then increases
102. The unit step response of the transfer function $1/s^2 + 2s + 3$
- has a non-zero slope at a origin
 - has a damped oscillatory characteristic
 - is overdamped
 - is unstable
103. The characteristic equation for the system is $s^3 + 9s^2 + 26s + 12(2 + K_c) = 0$. Using Routh test, the value of K_c that will keep the system on the verge of instability is
- 20.9
 - 18.4
 - 17.5
 - 15.3
104. The inverse Laplace transform of $1/2s^2 + 3s + 1$ is
- $e^{-t} - e^{-t}$
 - $2e^{-t} - e^{-t}$
 - $e^{-t} - 2e^{-t}$
 - $e^{-t} - e^{-t}$
105. The characteristic equation of a closed-loop system using a proportional controller with gain K_c is $12s^3 + 19s^2 + 8s + 1 + K_c = 0$. At the onset of instability, the value of K_c is
- 35/3
 - 10
 - 25/3
 - 20/3

106. Elements which are good catalysts and have the ability to change their oxidation number are
- transition elements
 - Nobel gases
 - alkalis
 - all of them
107. In Haber process bonds between ammonia and iron surface weaken and break during
- adsorption
 - chemisorptions
 - both (a) and (b)
 - desorption
108. Select the incorrect statement from the following option.
- Oils are saturated triglyceride
 - Oils have lower melting points
 - Oils are liquid at room temperature
 - Examples of oils are glyceryl trioleate, coconut oil, olive oil, etc
109. Hydrogenolysis is a reaction which leads to the reduction products of _____
- Aldehyde
 - Ketone
 - Alcohol
 - Ester
110. Richert-Meissl number is defined as the volume of 0.1 M KOH solution required for the neutralisation of _____ gram/grams of fat or oil.
- 1
 - 5
 - 100
 - 1000
111. The loss in cell mass due to oxidation of internal storage products for energy is known as
- Oxygen uptake rate
 - degradation coefficient
 - synthesis yield coefficient
 - endogenous decay coefficient
112. Act regulates the use and disposal of biosolids from wastewater treatment plant is
- Water Quality Act
 - Clean Water Act
 - 40 CFR Part 503
 - Total maximum daily load section of Clean Water Act
113. Modified Ludzack-Ettinger process is
- Post anoxic denitrification
 - Pre anoxic denitrification
 - Anoxic denitrification
 - Anaerobic denitrification
114. Act establishes air emission limits for sludge incinerators
- Clean Air Act
 - 40 CFR Part 60
 - 40 CFR Part 503
 - Air Quality Act
115. The works of Pasquill and Gifford states the level of atmospheric stability for Category D is
- Slightly stable
 - Moderately stable
 - Neutral
 - Slightly unstable