

पुस्तिका में पृष्ठों की संख्या : 16
Number of Pages in Booklet : 16

प्रश्न-पत्र पुस्तिका संख्या /
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Paper - III

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प्रश्न-पत्र पुस्तिका एवं उत्तर पत्रक के पेपर सील/पॉलिथीन बैग को खोलने पर परीक्षार्थी यह सुनिश्चित कर लें कि उसके प्रश्न-पत्र पुस्तिका पर वही प्रश्न-पत्र पुस्तिका संख्या अंकित है जो उत्तर पत्रक पर अंकित है। इसमें कोई भिन्नता हो तो परीक्षार्थी वीक्षक से दूसरा प्रश्न-पत्र प्राप्त कर लें। ऐसा सुनिश्चित करने की जिम्मेदारी अभ्यर्थी की होगी।

On opening the paper seal/polythene bag of the Question Paper Booklet the candidate should ensure that Question Paper Booklet No. of the Question Paper Booklet and Answer Sheet must be same. If there is any difference, candidate must obtain another Question Paper Booklet from Invigilator. Candidate himself shall be responsible for ensuring this.

परीक्षार्थियों के लिए निर्देश

- सभी प्रश्नों के उत्तर दीजिए।
- सभी प्रश्नों के अंक समान हैं।
- प्रत्येक प्रश्न का केवल एक ही उत्तर दीजिए।
- एक से अधिक उत्तर देने की दशा में प्रश्न के उत्तर को गलत माना जाएगा।
- प्रत्येक प्रश्न के चार वैकल्पिक उत्तर दिये गये हैं, जिन्हें क्रमशः 1, 2, 3, 4 अंकित किया गया है। अभ्यर्थी को सही उत्तर निर्दिष्ट करते हुए उनमें से केवल एक गोले अथवा बबल को उत्तर पत्रक पर नीले बॉल प्वाइंट पेन से गहरा करना है।
- OMR उत्तर पत्रक इस परीक्षा पुस्तिका के अन्दर रखा है। जब आपको परीक्षा पुस्तिका खोलने को कहा जाए, तो उत्तर-पत्रक निकाल कर ध्यान से केवल नीले बॉल पॉइंट पेन से विवरण भरें।
- प्रत्येक गलत उत्तर के लिए प्रश्न अंक का 1/3 भाग काटा जायेगा। गलत उत्तर से तात्पर्य अशुद्ध उत्तर अथवा किसी भी प्रश्न के एक से अधिक उत्तर से है। किसी भी प्रश्न से संबंधित गोले या बबल को खाली छोड़ना गलत उत्तर नहीं माना जायेगा।
- मोबाइल फोन अथवा इलेक्ट्रॉनिक यंत्र का परीक्षा हॉल में प्रयोग पूर्णतया वर्जित है। यदि किसी अभ्यर्थी के पास ऐसी कोई वर्जित सामग्री मिलती है तो उसके विरुद्ध आयोग द्वारा नियमानुसार कार्यवाही की जायेगी।
- कृपया अपना रोल नम्बर ओ.एम.आर. पत्रक पर सावधानीपूर्वक सही भरें। गलत अथवा अपूर्ण रोल नम्बर भरने पर 5 अंक कुल प्राप्तांकों में से काटे जा सकते हैं।

चेतावनी: अगर कोई अभ्यर्थी नकल करते पकड़ा जाता है या उसके पास से कोई अनधिकृत सामग्री पाई जाती है, तो उस अभ्यर्थी के विरुद्ध पुलिस में प्राथमिकी दर्ज कराते हुए विविध नियमों-प्रावधानों के तहत कार्यवाही की जाएगी। साथ ही विभाग ऐसे अभ्यर्थी को भविष्य में होने वाली विभाग की समस्त परीक्षाओं से विवर्जित कर सकता है।

INSTRUCTIONS FOR CANDIDATES

- Answer all questions.
- All questions carry equal marks.
- Only one answer is to be given for each question.
- If more than one answers are marked, it would be treated as wrong answer.
- Each question has four alternative responses marked serially as 1, 2, 3, 4. You have to darken only one circle or bubble indicating the correct answer on the Answer Sheet using BLUE BALL POINT PEN.
- The OMR Answer Sheet is inside this Test Booklet. When you are directed to open the Test Booklet, take out the Answer Sheet and fill in the particulars carefully with blue ball point pen only.
- 1/3 part of the mark(s) of each question will be deducted for each wrong answer. A wrong answer means an incorrect answer or more than one answers for any question. Leaving all the relevant circles or bubbles of any question blank will not be considered as wrong answer.
- Mobile Phone or any other electronic gadget in the examination hall is strictly prohibited. A candidate found with any of such objectionable material with him/her will be strictly dealt as per rules.
- Please correctly fill your Roll Number in O.M.R. Sheet. 5 Marks can be deducted for filling wrong or incomplete Roll Number.

Warning: If a candidate is found copying or if any unauthorized material is found in his/her possession, F.I.R. would be lodged against him/her in the Police Station and he/she would liable to be prosecuted. Department may also debar him/her permanently from all future examinations.

इस परीक्षा पुस्तिका को तब तक न खोलें जब तक कहा न जाए।

Do not open this Test Booklet until you are asked to do so.



1. A circular pipe of I.D. 4 m is bifurcated into two pipes of I.D. 2 m each. If the average velocity of water flowing through the main pipe is 5 m/s, then the average velocity through the bifurcated pipe is
 (1) 20 m/s (2) 10 m/s
 (3) 7.07 m/s (4) 5 m/s
2. In constant pressure filtration, the rate of filtration follows the relation (v : filtrate volume; t : time; k and C : constants)
 (1) $\frac{dv}{dt} = kv + C$ (2) $\frac{dv}{dt} = kv^2$
 (3) $\frac{dv}{dt} = kv$ (4) $\frac{dv}{dt} = \frac{1}{kv + C}$
3. A venturi meter (discharge coefficient = 0.98) is installed to measure the flow rate of water (density = 1000 kg/m³) in a 200 mm diameter (ID) pipe. The throat diameter is 100 mm. The differential pressure measured by using a manometer is 150 kN/m². The volumetric flow rate of water (in m³/s) is
 (1) 0.14 (2) 0.20
 (3) 0.41 (4) 0.24
4. For fanning friction factor f (for flow in pipes) and drag co-efficient C_D (for flow over immersed bodies) which of the following statements are true?
 P : f accounts only for the skin friction
 Q : C_D accounts only for the skin friction
 R : C_D accounts for both skin friction and form friction
 S : Both f and C_D depend on the Reynolds number
 T : For laminar flow through a pipe, f doubles on doubling the volumetric flow rate
 (1) R, S, T (2) P, Q, S
 (3) P, R, S (4) P, Q, S, T

5. Which of the following statements are correct?
 P : For a rheopectic fluid, the apparent viscosity increases with time under a constant applied shear stress.
 Q : For a pseudoplastic fluid, the apparent viscosity decreases with time under a constant applied shear stress.
 R : For a Bingham plastic, the apparent viscosity increases exponentially with the deformation rate.
 S : For a dilatant fluid, the apparent viscosity increases with increasing deformation rate.
 (1) P and Q only (2) Q and R only
 (3) R and S only (4) P and S only
6. The thermal efficiency of a reversible heat engine operating between two given thermal reservoirs is 0.4. The device is used either as a refrigerator or as a heat pump between the same reservoirs. The co-efficients of performance as a refrigerator (COP)_R and the Co-efficient of Performance as a heat pump (COP)_{HP} are
 (1) (COP)_R = (COP)_{HP} = 0.6
 (2) (COP)_R = 2.5; (COP)_{HP} = 1.5
 (3) (COP)_R = 1.5; (COP)_{HP} = 2.5
 (4) (COP)_R = (COP)_{HP} = 2.5
7. The heat flux (from outside to inside) across an insulating wall with thermal conductivity $k=0.04$ W/m K and thickness 0.16 m is 10 W/m². The temperature of the inside wall is -5 °C. The outside wall temperature is
 (1) 25 °C (2) 30 °C
 (3) 35 °C (4) 40 °C

8. A composite wall consists of two plates A and B placed in series normal to the flow of heat. The thermal conductivities are k_A and k_B and the specific heat capacities are C_{pA} and C_{pB} , for plates A and B respectively. Plate B has twice the thickness of plate A. At steady state, the temperature difference across the plate A is greater than that across the plate B when
- (1) $C_{pA} > C_{pB}$ (2) $C_{pA} < C_{pB}$
 (3) $k_A < 0.5 k_B$ (4) $k_A > 2k_B$
9. In a counter-flow double pipe heat exchanger, oil ($m = 2 \text{ kg/s}$, $C_p = 2.1 \text{ kJ/kg}\cdot^\circ\text{C}$) is cooled from 90°C to 40°C by water ($m = 1 \text{ kg/s}$, $C_p = 4.2 \text{ kJ/kg}\cdot^\circ\text{C}$) which enters the inner tube at 10°C . The radius of the inner tube is 3 cm and its length is 5 m. Neglecting the wall resistance, the overall heat transfer co-efficient based on the inner radius, in $\text{kW/m}^2 \text{K}$, is
- (1) 0.743 (2) 7.43
 (3) 74.3 (4) 2475
10. Let us assume two walls of same thickness and same cross-sectional area having thermal conductivities in the ratio 1 : 2. Let us say there is same temperature difference across the wall faces, the ratio of heat flow will be
- (1) 1 : 2 (2) 1 : 1
 (3) 2 : 1 (4) 4 : 1
11. In turbulent flow through a tube, flow velocity is increased two times. The change in heat transfer co-efficient will be
- (1) 64.1% decrease
 (2) 74.1% increase
 (3) 74.1% decrease
 (4) 64.1% increase
12. A pipe of 25 mm diameter carries steam. The heat transfer co-efficient between the cylinder and surrounding is $5 \text{ W/m}^2\text{K}$. It is proposed to reduce the heat loss from the pipe by adding insulation having a thermal conductivity of 0.05 W/mK . Which one of the following statement is True ?
- (1) The outer radius of the pipe is equal to the critical radius.
 (2) The outer radius of the pipe is less than the critical radius.
 (3) Adding the insulation will reduce the heat loss.
 (4) Adding the insulation will increase the heat loss.
13. An oil cooler in a high performance engine has an outside surface area of 0.12 m^2 and a surface temperature of 65°C . At any time, air moves over the surface of the cooler at a temperature of 30°C and the heat transfer co-efficient is equal to $45.4 \text{ W/m}^2\text{K}$. Find out the heat transfer rate.
- (1) 238.43 W (2) 190.68 W
 (3) 543.67 W (4) 675.98 W
14. In a counter-current double pipe heat exchanger, the hot fluid inlet and outlet temperatures are 80°C and 60°C . The cold fluid inlet and outlet temperatures are 20°C and 40°C . What is LMTD ?
- (1) 20°C (2) 30°C
 (3) 36.4°C (4) 40°C

15. Water enters a thin walled tube ($L = 1$ m, $D = 3$ mm) at an inlet temperature of 97°C and mass flow rate of 0.015 kg/s. The tube wall is maintained at a constant temperature of 27°C .

Given : density of water = 1000 kg/m³;
viscosity of water = 489×10^{-6} Pa.s,
specific heat of water = 4184 J/kg/k;
inside heat transfer co-efficient = 12978 W/(m²K). The outlet temperature of water in $^\circ\text{C}$ will be

- (1) 28 (2) 96
(3) 62 (4) 37

16. A solid at a temperature T_1 is kept in an evacuated chamber at a temperature of T_2 ($> T_1$). The rate of increase in the temperature of the body is proportional to

- (1) $T_2 - T_1$ (2) $T_2^2 - T_1^2$
(3) $T_2^3 - T_1^3$ (4) $T_2^4 - T_1^4$

17. The unit of resistance to heat transfer is

- (1) W/K (2) $\text{W}^{-1}\text{K}^{-1}$
(3) WK (4) K/W

18. The surface renewal frequency in Danckwerts' model of mass transfer is given by (k_L ; mass transfer co-efficient, m/s); D_A = Diffusivity, m²/s)

- (1) $\sqrt{k_L^2 D_A}$ (2) $k_L^2 D_A$
(3) $\frac{k_L^2}{D_A}$ (4) $\frac{k_L}{D_A^2}$

19. The Lewis relation for air-water humidification is given by (k_y : mass transfer co-efficient of moisture in air; h_G : heat transfer co-efficient; C_S : heat capacity of vapour gas mixture)

- (1) $\frac{h_G^2}{k_y C_S} = 1$ (2) $\frac{k_y C_S^2}{h_G} = 1$
(3) $\frac{h_G}{k_y C_S} = 1$ (4) $\frac{k_y^2 h_G}{C_S} = 1$

20. According to the Fenske equation, what will be the minimum number of plates required in a distillation column to separate an equimolar binary mixture of components A & B into an overhead fraction containing 99 mole % A and a bottoms fraction containing 98 mole % B ? [Assume that the relative volatility ($\alpha_{AB} = 2$) does not change appreciably in the column]

- (1) 5 (2) 9
(3) 12 (4) 28

21. In a binary mixture containing components A and B, the relative volatility of A with respect to B is 2.5 when mole fractions are used. The molecular weights of A and B are 78 and 92 respectively. If the compositions are however expressed in mass fractions the relative volatility will then be

- (1) 1.18 (2) 2.12
(3) 2.5 (4) 2.95



22. H_2S is being absorbed in a gas absorber unit. The height of the transfer unit based on the overall mass transfer co-efficient on the gas side is 0.4 m. The equilibrium data is 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

- (1) 2.0 (2) 1.56
 (3) 1.0 (4) 0.56

23. In an absorption column, the flooding velocity for random packing is _____ that for stacked/regular packing.

- (1) Greater than
 (2) Smaller than
 (3) Equal to
 (4) Either Greater than, or Smaller than; depends on the type of packing

24. Find the distillate and the residue rates in mole/hr, if the feed rate is 100 mol/hr; The compositions of feed, distillate and residue in terms of mole fraction are 0.65, 0.9 and 0.2

- (1) 36, 64 (2) 64, 36
 (3) 20, 80 (4) 80, 20

25. Steam distillation is not recommended to be used, if the

- (1) material cannot be distilled by indirect heating even under low pressure, because of the high boiling temperature.
 (2) liquids decompose, if distilled directly at atmospheric pressure.
 (3) azeotropic mixture is to be separated and the final product is miscible with water.
 (4) material to be distilled is thermally unstable or has the tendency to react with other components associated with it, at the boiling temperature.

26. Benzene is removed from air by absorbing it in a non-volatile wash-oil at 100 kPa in a countercurrent gas absorber. Gas flow rate is 100 mol/min, which includes 2 mol/min of benzene. The flow rate of wash-oil is 50 mol/min. Vapour pressure of benzene at the column conditions is 50 kPa. Benzene forms an ideal solution with the wash-oil and the column is operating at steady state. Gas phase can be assumed to follow Raoult's law. Neglect the change in molar flow rates of liquid and gas phases inside the column. For this process, the value of the absorption factor (upto two decimal places) is

- (1) 0.02 (2) 2.02
 (3) 1.02 (4) 0.22

27. An ideal flash vaporization is carried out with a binary mixture at constant temperature and pressure. A process upset leads to an increase in the mole fraction of the heavy component in the feed. The flash vessel continues to operate at the previous temperature and pressure and still produces liquid and vapour. After steady state is re-established,

- (1) The amount of vapour produced will increase.
 (2) The amount of liquid produced will decrease.
 (3) The new equilibrium compositions of the vapour and liquid products will be different.
 (4) The new equilibrium compositions of the vapour and liquid products will remain as they were before the upset occurred.

28. In azeotropic distillation the third component is added
- (1) To form another azeotrope with one of the components.
 - (2) To increase the value of relative volatility of the original two components.
 - (3) To decrease the value of relative volatility of the original two components.
 - (4) To change the value of the vaporization equilibrium constant of the two components.
29. If the percent humidity of air (30 °C, total pressure 100 kPa) is 24% and the saturation pressure of water vapour at that temperature is 4 kPa, the percent relative humidity and the absolute humidity of air are
- (1) 20.7, 0.0055
 - (2) 25, 0.0035
 - (3) 24.75, 0.0062
 - (4) 18.2, 0.0035
30. The conversion for a second order, irreversible reaction (constant volume) $A \xrightarrow{k_2} B$, in batch mode is given by
- (1) $\frac{1}{1 + k_2 C_{A0}t}$
 - (2) $\frac{k_2 C_{A0}t}{1 + k_2 C_{A0}t}$
 - (3) $\frac{(k_2 C_{A0}t)^2}{1 + k_2 C_{A0}t}$
 - (4) $\frac{k_2 C_{A0}t}{(1 + k_2 C_{A0}t)^2}$
31. For a series of reactions $A \xrightarrow{k_1} B \xrightarrow{k_2} C$ having $k_1 \ll k_2$, the reaction system can be approximated as
- (1) $A \xrightarrow{k_1} B$
 - (2) $A \xrightarrow{k_2} B$
 - (3) $A \xrightarrow{k_2} C$
 - (4) $A \xrightarrow{k_1} C$
32. For an isothermal second order aqueous phase reaction $A \rightarrow B$, the ratio of the time required for 90% conversion to the time required for 45% conversion is
- (1) 2
 - (2) 4
 - (3) 11
 - (4) 22

33. The liquid phase reaction, $A \rightarrow$ Products is governed by $r_A = kC_A^{1/2}$. If the reaction undergoes 75% conversion of A in 10 min in an isothermal batch reactor, then the time (in min) required for the complete conversion of A is
- (1) 40/3
 - (2) 20
 - (3) 30
 - (4) ∞
34. In an aqueous solution, reaction $P \rightarrow Q$ occurs under isothermal conditions following first order kinetics. The feed rate is 500 cm³/min and concentration of P in the feed is 1.5×10^{-4} mol/cm³. The reaction is carried out in a 5 L CSTR. At steady state, 60% conversion is observed. The rate constant (in min⁻¹) is
- (1) 0.06
 - (2) 0.28
 - (3) 0.21
 - (4) 0.15
35. The half-life of a first order liquid phase reaction is 30 s. The rate constant in min⁻¹, is
- (1) 0.0231
 - (2) 0.602
 - (3) 1.386
 - (4) 2.0
36. To maximize the formation of R in the simultaneous reactions
- $$A + B \rightarrow R \quad r_R = 2C_A^{0.5} C_B^2$$
- $$A + B \rightarrow S \quad r_S = 1.5C_A C_B$$
- We should have
- (1) Low C_A , Low C_B
 - (2) Low C_A , High C_B
 - (3) High C_A , Low C_B
 - (4) High C_A , High C_B

37. 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 uniform pressure) is

- (1) 0.60 (2) 0.30
(3) 0.35 (4) 0.47

38. The first order gas phase reaction, $A \xrightarrow{k_1} 2B$ is conducted isothermally in batch mode at constant volume. The rate of change of conversion with time is given by

- (1) $dX_A/dt = k_1 (1 - X_A)^2 (1 + 2X_A)$
(2) $dX_A/dt = k_1 (1 - X_A) (1 + 0.5X_A)$
(3) $dX_A/dt = k_1 (1 - X_A) / (1 + X_A)$
(4) $dX_A/dt = k_1 (1 - X_A)$

39. An irreversible first order reaction is being carried out in a CSTR and PFR of same volume. The liquid flow rates are same. The relative conversion will

- (1) be more in CSTR than in PFR
(2) be more in PFR than in CSTR
(3) be same in both cases
(4) depend on the temperature

40. In a first order reaction, the time required to reduce the concentration of reactant from 1 mole/liter to 0.5 mole/liter will be _____ that required to reduce it from 10 moles/liter to 5 moles/liter in the same volume.

- (1) more than
(2) less than
(3) same as
(4) data insufficient; can't be predicted

41. Pick out the wrong statement

- (1) In a continuous flow reactor, both the reactants and the products flow out continuously.
(2) In a continuous flow reactor, uniform concentration cannot be maintained throughout the vessel even in a well agitated system.
(3) In a semi-batch reactor, one reactant is charged batch wise, while the other reactant is fed continuously.
(4) In a batch reactor, which is exclusively used for liquid phase reactions; temperature pressure and composition may vary with time.

42. Heat integration is planned in a process plant at an investment ₹ 2×10^6 . This would result in a net energy savings of 20 GJ per year. If the nominal rate of interest is 15% and the plant life is 3 years, then the breakeven cost of energy, in ₹ per GJ (adjusted to the nearest hundred), is

- (1) 33500 (2) 48300
(3) 54200 (4) 65400

43. A column costs ₹ 5.0 lakhs and has a useful life of 10 years. Using the double declining balance depreciation method, the book value of the unit at the end of five years (in lakhs of ₹) is

- (1) 1.21 (2) 1.31
(3) 1.64 (4) 2.05

44. The cost of a distillation column in the year 2000 is x rupees. What is the cost of the column in rupees in the year 2010 given the cost indices for the years 2000 and 2010 are 480 and 520 respectively ?

- (1) $(520/480)^2 x$ (2) $(480/520) x$
(3) $(520/480) x$ (4) $(520/480)^{0.6} x$



45. Which of the following relationship is not correct is case of a chemical process plant ?
- (1) Manufacturing cost = direct product cost + fixed charges + plant overhead costs
 - (2) General expenses = administrative expenses + distribution & marketing expenses
 - (3) Total product cost = manufacturing cost + general expenses
 - (4) Total product cost = direct production cost + plant overhead cost
46. Which of the following is not a component of the fixed capital for a chemical plant facility ?
- (1) Raw materials inventory
 - (2) Process equipments
 - (3) Utilities plants
 - (4) Contingency
47. What will be the total amount available 10 years from now if ₹ 1 is deposited at the present time with nominal interest rate of 11% compounded continuously ?
- (1) $\exp(110)$
 - (2) $\exp(1.1)$
 - (3) $10 \exp(0.11)$
 - (4) $10 \ln(11)$
48. Break-even point is the point of intersection of
- (1) Fixed cost and total cost
 - (2) Fixed cost and sales revenue
 - (3) Total cost and sales revenue
 - (4) Fixed charges and plant overhead costs
49. In a cylindrical vessel subjected to internal pressure, the longitudinal stress (σ_L), and the circumferential stress (σ_h) are related by
- (1) $\sigma_h = \sigma_L/3$
 - (2) $\sigma_h = \sigma_L$
 - (3) $\sigma_h = 2 \sigma_L$
 - (4) $\sigma_h = \frac{1}{2} \sigma_L$
50. For shell-and-tube heat exchangers, with increasing the heat transfer area, the purchased cost per unit heat transfer
- (1) Increases
 - (2) Passes through a maxima
 - (3) Remains constant
 - (4) Decreases
51. A suitable material of construction to use with fuming sulphuric acid
- (1) Nickel
 - (2) Carbon steel
 - (3) Stainless steel type 304
 - (4) Monel
52. Discounted cash flow analysis is used to calculate
- (1) The present worth of future earnings
 - (2) The future worth of present investment
 - (3) The payback period
 - (4) The life of the project
53. The total capital investment for a chemical plant is ₹ 10,00,000, and the working capital is ₹ 1,00,000. For an asset turnover ratio of 1, the gross annual sale will be
- (1) ₹ 90,000
 - (2) ₹ 11,00,000
 - (3) ₹ 10,00,000
 - (4) ₹ 1,00,000
54. The root locus plot of the roots of the characteristics equation of a closed loop system having the open loop transfer function $\frac{K(s+1)}{2(2s+1)(3s+1)}$ will have a definite number of loci for variation of K from 0 to ∞ . The number of loci is
- (1) 1
 - (2) 3
 - (3) 4
 - (4) 2

55. Stability of a control system containing a transportation lag can be best analysed by

- (1) Routh test
- (2) Root locus method
- (3) Frequency response method
- (4) None of these

56. Which of the following thermocouples is capable of measuring a temperature of -50°C ?

- (1) Platinum – platinum + rhodium
- (2) Chromel – alumel
- (3) Iron – constantan
- (4) Copper – constantan

57. 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 taking the values of process gain, time constant and dead time as

- (1) 8, 0.6, 0.08
- (2) 12, 0.6, 0.12
- (3) 8, 0.6, 0.12
- (4) 12, 0.4, 0.08

58. Step response of a second order system shows 37% overshoot. The value of damping factor is

- (1) 0.37
- (2) 0.5
- (3) 0.3
- (4) 0.2

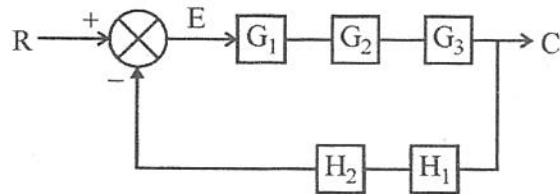
59. Step response of a first order process $G_p = 2/(3s + 1)$ for a unit step change in input is

- (1) $y = 1 - \exp(-t/3)$
- (2) $y = 2(1 - \exp(-3t))$
- (3) $y = 1 - \exp(-3t)$
- (4) $y = 2(1 - \exp(-t/3))$

60. Pick out the first order system from the followings :

- (1) Damped vibrator
- (2) Interacting system of two tanks in series
- (3) Mercury in glass thermometer kept in boiling water.
- (4) Non-interacting system of two tanks in series.

61. What is the overall transfer function (C/R) of the following block diagram if $G = G_1 \cdot G_2 \cdot G_3$ and $H = H_1 \cdot H_2$.



- (1) $1/(1 + GH)$
- (2) $G/(1 + GH)$
- (3) $H/(1 + GH)$
- (4) $G/(1 - GH)$

62. The smallest change in the value of input variable being measured, that will cause a change in the output signal of the instrument is termed as

- (1) Hysteresis
- (2) Drift
- (3) Resolution
- (4) Threshold

63. Match the measured process variables in Group I with the list of measuring devices given in Group II.

Group I		Group II				
A. Temperature	1. Bourdon tube element					
B. Pressure	2. Orifice plates					
C. Flow	3. Infrared analyzer					
D. Liquid level	4. Displacer devices					
E. Composition	5. Pyrometer					
	A	B	C	D	E	
(1)	5	1	2	4	3	
(2)	3	1	4	2	5	
(3)	1	3	4	2	5	
(4)	3	1	2	4	5	

64. The relationship between kinematic viscosity (ν) and dynamic viscosity (μ) is

- (1) μ (centistokes) = ν (centipoise)/ ρ (g/cm^3)
- (2) ν (centistokes) = μ (centipoise)/ ρ (g/cm^3)
- (3) μ (centipoise) = ν (centistokes)/ ρ (kg/m^3)
- (4) ν (strokes) = μ (poise) $\times \rho$ (kg/m^3)

65. The unit impulse response of a first order process is given by $2e^{-0.5t}$. The gain and time constant of the process are, respectively,

- (1) 4 and 2
- (2) 2 and 2
- (3) 2 and 0.5
- (4) 1 and 0.5

66. The most important process currently used for industrial production of carbon black from petroleum oil is

- (1) furnace black process
- (2) channel black process
- (3) lamp black process
- (4) acetylene black process

67. Crude petroleum consists of

- (1) 84-87 per-cent carbon and 11-14 per-cent hydrogen
- (2) 11-14 per-cent carbon and 84-87 per-cent hydrogen
- (3) 54 per-cent carbon and 25 per-cent hydrogen
- (4) 70-72 per-cent carbon and 5-7 per-cent hydrogen

68. Which is the most undesirable component in kerosene?

- (1) Aromatics
- (2) i-paraffins
- (3) n-paraffins
- (4) Naphthenes

69. Cetane number of high speed diesel must be greater than and equal to (\geq)

- (1) 30
- (2) 45
- (3) 75
- (4) 95

70. Petroleum liquid fuels having flash point greater than 66°C is considered as safe during storage and handling. Which of the following has flash point $> 66^\circ\text{C}$?

- (1) Naphtha
- (2) Petrol
- (3) Kerosene
- (4) Heavy fuel oil

71. Sweetening of petroleum product means removal of

- (1) Water
- (2) Wax
- (3) Organic Impurities
- (4) Sulphur & its compounds

72. Pick out the wrong statement

- (1) All the nitrogenous fertilizers are not soluble in water.
- (2) A straight fertilizer contains only one nutrient.
- (3) Calcium cyanamide is used as weed killer in onion fields.
- (4) The phosphorous nutrient makes the plant stem stronger and increases its branches.

73. What products do we get on electrolysis of saturated brine using steel cathode and graphite anode in electrolytic cell?

- (1) Cl_2 & Na
- (2) Cl_2 & H_2
- (3) O_2 & H_2
- (4) Cl_2 , H_2 & NaOH

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

- (1) 2-5%
- (2) 7-10%
- (3) 12-15%
- (4) 20-25%

75. The proper arrangement of the petroleum fractions, in terms of their boiling points is

- (1) Lubricating oils > diesel > petrol > LPG
- (2) Lubricating oils > petrol > diesel > LPG
- (3) Petrol > lubricating oil > diesel > LPG
- (4) Petrol > diesel > LPG > lubricating oil

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

Group I	Group II
A. Urea	1. Ammonia and carbon dioxide
B. Polyester	2. Dimethyl terephthalate and ethylene glycol
	3. Ammonia and carbon monoxide
	4. Hexamethylene diamine and adipic acid
(1) A-1, B-4	(2) A-3, B-2
(3) A-3, B-4	(4) A-1, B-2

77. Match the petrochemical derivative in Group I with the raw materials in Group II.

Group I	Group II
P. Acrylonitrile	1. Methane
Q. Ammonia	2. Ethane
R. Dodecane	3. Ethylene
	4. Propylene
(1) P-1, Q-2, R-1	(2) P-2, Q-1, R-2
(3) P-3, Q-4, R-3	(4) P-4, Q-1, R-4

78. Septic tanks are primarily used for

- (1) the aerobic decomposition of deposited sewage solids.
- (2) separation of deposited solids.
- (3) anaerobic decomposition of deposited solids.
- (4) separation of oil and grease scums.

79. Which of the following particulate collection devices does not discharge the collected particulates as dry solid ?

- (1) Cyclone separator
- (2) Electrostatic precipitator
- (3) Wet scrubber
- (4) Fabric filter

80. Chloramines are used in water treatment

- (1) for disinfection
- (2) for taste and colour control
- (3) as algicides
- (4) for weed control in reservoirs

81. The main pollutant in the discharged waste water from a petroleum refinery is oil (both in free and emulsified form). Free oil is removed by

- (1) trickling filters.
- (2) aerated lagoons.
- (3) biological oxygen pond.
- (4) gravity separator having oil skimming devices.

82. There are thirteen metals which are treated as pollutants. Which of the following metal is not a pollutant ?

- (1) Mercury
- (2) Arsenic
- (3) Aluminium
- (4) Lead

83. If BOD of river water is high, then it implies that river water is
- (1) polluted with pesticides
 - (2) not at all polluted
 - (3) highly polluted with inorganic chemicals
 - (4) highly polluted with biodegradable organic chemicals
84. Industrial chimney located near tall building should be at least _____ times the height of building.
- (1) 0.5
 - (2) 2.5
 - (3) 4
 - (4) 5.5
85. What is BOD of a water sample having initial oxygen concentration of 10 ppm and final oxygen concentration of 4 ppm after keeping it in a close bottle for 6 days at 25 °C ?
- (1) 2.5
 - (2) 6
 - (3) 14
 - (4) 1.5
86. The total hardness of soft water as CaCO₃ equivalent is
- (1) 50 ppm
 - (2) 100 ppm
 - (3) 150 ppm
 - (4) 200 ppm
87. The following is not used for removing the permanent hardness :
- (1) Lime soda process
 - (2) Zeolite process
 - (3) Demineralization
 - (4) Addition of lime
88. The gas, which is produced predominantly in the aerobic digestion of sludge is
- (1) NO₂
 - (2) CO₂
 - (3) O₂
 - (4) H₂S
89. Which of the following air pollution control device has the maximum efficiency ?
- (1) Electrostatic precipitator
 - (2) Dynamic precipitator
 - (3) Spray tower
 - (4) Wet cyclonic scrubber
90. All containers or laboratory glassware having chemicals in them should be properly labelled. When should you place a label on a container ?
- (1) After adding a chemical to the container.
 - (2) Prior to adding a chemical to the container.
 - (3) During use of the chemical in the container.
 - (4) After the container has been emptied.
91. Water is used to extinguish
- (1) Class-A fires
 - (2) Class-B fires
 - (3) Class-C fires
 - (4) All of these
92. Solvents such as Tetrahydrofuran and ethyl ether are particularly hazardous because
- (1) they are flammable.
 - (2) they form explosive peroxides when exposed to air.
 - (3) they penetrate the skin.
 - (4) All of these
93. A "Class-D" fire extinguisher can be used to treat fires involving _____ as fuel sources.
- (1) ordinary combustibles (woods, plastics, etc.)
 - (2) electrical equipment
 - (3) combustible metals
 - (4) flammable or combustible liquids

94. The _____ process determines whether exposure to a chemical can increase the incidence of adverse health effect.
- (1) Hazard identification
 - (2) Exposure assessment
 - (3) Toxicity assessment
 - (4) Risk characterization
95. What should you do in an event involving spill of hazardous material during transportation ?
- (1) Send someone for help and warn others of the danger.
 - (2) Move leaking material out of the way even if it is unsafe to do so.
 - (3) Move your truck/trailer far away from the scene.
 - (4) Try to extinguish any fires.
96. Eye protection is required for which of the following hazards ?
- (1) Flying particles
 - (2) Liquid chemicals, acids or caustic liquids
 - (3) Chemical gases or vapours
 - (4) All of these
97. This symbol warns against which of the following hazards ?



- (1) Hazardous to both living and non-living material
- (2) Dangerous liquid, don't touch
- (3) Acidic
- (4) Corrosive

98. OSHA stands for
- (1) Occasional Safety and Health Association
 - (2) Occupational Safety and Health Administration
 - (3) Occupational Satisfaction and Health Administration
 - (4) Occasional Safety and High risk Association
99. Air contains 5 ppm of diethylamine [threshold limit value (TLV)-time-weighted average (TWA) = 10 ppm], 10 ppm of cyclohexanol (TLV-TWA = 50 ppm), and 20 ppm of propylene oxide (TLV-TWA = 20 ppm). The mixture TLV-TWA will be
- (1) 20.59
 - (2) 43.75
 - (3) 22.86
 - (4) 35.00
100. The limiting oxygen concentration (LOC) of butane (C_4H_{10} ; lower flammable limit, $LFL_{butane} = 1.9$ vol.%) is
- (1) 12.35 vol.%
 - (2) 18.65 vol.%
 - (3) 16.22 vol.%
 - (4) 14.35 vol.%
101. Hazard identification mainly focus on
- (1) Chemical pathway
 - (2) Chemical exposure
 - (3) Chemical analysis
 - (4) Chemical source and concentration

102. A mixture contains 23 g of ethanol and 36 g of water. Some acetic acid is added to the mixture and its mole fraction becomes 0.5. How much acetic acid was added ?

- (1) 25 g (2) 75 g
(3) 100 g (4) 150 g

103. For a reversible process,

- (1) $dS = dQ/T$
(2) $dS > dQ/T$
(3) $dS < dQ/T$
(4) None of the mentioned

104. A solution has 25% w/w Sodium Chloride in 10 grams of water. What is the mole fraction of Sodium Chloride ?

- (1) 0.05 (2) 0.06
(3) 0.07 (4) 0.08

105. Calculate the change in enthalpy of carbon dioxide from 30 °C to 1500 °C at 100 kPa at constant specific heat of 0.842 kJ/kgK

- (1) 1237.7 kJ/kg (2) 1637.7 kJ/kg
(3) 2237.7 kJ/kg (4) 2337.7 kJ/kg

106. For a given system, number of variables is 6 and number of equations is 4. What is the number of degrees of freedom ?

- (1) 2 (2) 4
(3) 6 (4) 8

107. A cellulose solution contains 5.2% cellulose by weight in water. How many kilograms of 1.2% solution are required to dilute 100 kg of 5.2% solution to 4.2% ?

- (1) 23.3 (2) 33.3
(3) 66.6 (4) 83.3

108. A reaction $A + B \rightleftharpoons C + D$ is carried out in a batch reactor. Initially, 1 mole of A and 2 mole of B are fed. At equilibrium, the product C is obtained as 0.6 mole. The equilibrium constant is :

- (1) $K = 14/9$ (2) $K = 9/14$
(3) $K = 9/4$ (4) $K = 0.18$

109. Pick out the correct statements,

- (A) A closed system does not permit exchange of mass with its surroundings but may permit exchange of energy.
(B) An open system permits exchange of both mass and energy with its surroundings.
(C) The term microstate is used to characterise an individual, whereas macro-state is used to designate a group of micro-states with common characteristics.
(D) Melting of ice involves increase in enthalpy and a decrease in randomness.
(1) (A), (B) and (C) (2) (B) and (C)
(3) (A) and (C) (4) (D) only

110. Excess Gibbs energy of a binary solution is represent by $G^E/RT = Ax_1x_2$. The activity co-efficient of component 1 will be given by

- (1) $\gamma_1 = Ax_1^2$
(2) $\gamma_1 = Ax_2^2$
(3) $\gamma_1 = \exp(Ax_1x_2)$
(4) $\gamma_1 = \exp(Ax_2^2)$



111. The molecular weights of two components, A and B are 20 and 40, respectively. The relation between the weight fraction of A (W_A) and mole fraction of A (x_A) in their binary mixture is

$$(1) W_A = \frac{x_A}{2-x_A} \quad (2) W_A = \frac{2x_A}{2-x_A}$$

$$(3) W_A = \frac{1}{2-x_A} \quad (4) W_A = \frac{x_A}{1-x_A}$$

112. Which of the following equation is not a Maxwell's equation ?

$$(1) \left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

$$(2) \left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$$

$$(3) \left(\frac{\partial V}{\partial P}\right)_T = \left(\frac{\partial S}{\partial T}\right)_P$$

$$(4) \left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$$

113. An ideal gas is initially at a pressure of 0.1 MPa and a total volume of 2 m³. It is first compressed to 1 MPa by a reversible adiabatic process and then cooled at constant pressure to a final volume of 0.2 m³. The total work done (in kJ) on the gas for the entire process ($C_p = 2.5 R$) is

$$(1) -757.2 \quad (2) 577.2$$

$$(3) -577.2 \quad (4) 757.2$$

114. The Prandtl Number is the ratio of

- (1) Momentum diffusivity to thermal diffusivity
- (2) Thermal diffusivity to momentum diffusivity
- (3) Shear stress to thermal diffusivity
- (4) Thermal diffusivity to kinematic viscosity

115. Eddy viscosity is a turbulent transfer of _____.

- (1) Fluid
- (2) Heat
- (3) Momentum
- (4) Pressure

116. Fanning friction factor is _____.

- (1) 0.25 times Darcy friction factor
- (2) Same as Darcy friction factor
- (3) 2 times Darcy friction factor
- (4) Independent

117. The water flows through a pipe at a velocity of 2 m/s. The pressure gauge reading is 2 bar. The datum head is 2 m. Find the piezometric head. (Assume all Bernoulli's assumptions, Density of water = 1000 kg/m³, $g = 9.8 \text{ m/s}^2$).

- (1) 18.4 m
- (2) 28.6 m
- (3) 22.4 m
- (4) 20.6 m

118. The work required for crushing of solid is proportional to the new surface created. This is known as

- (1) Bond's law
- (2) Rittinger's law
- (3) Kick's law
- (4) None of these

119. The ratio of average fluid velocity to the maximum velocity in case of laminar flow of a Newtonian fluid in a circular pipe is

- (1) 0.66
- (2) 1
- (3) 2
- (4) 0.5

120. The hydraulic radius for flow in a rectangular duct of cross-sectional dimensions H and W is

- (1) $\sqrt{\frac{HW}{\pi}}$
- (2) $\frac{(HW)^2}{4(H+W)}$
- (3) $HW/[2(H+W)]$
- (4) $2HW/(H+W)$

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