NG 24 (GROUP B)

PART I — ENGINEERING MATHEMATICS

(Common to all Candidates)

(Answer ALL questions)

1. If A is a 3×3 matrix and determinant of A is 6, then find the value of the determinant of the matrix $(2A)^{-1}$

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

   b. $\frac{1}{24}$

   c. $\frac{1}{36}$

   d. $\frac{1}{48}$

2. If $3x+2y+z=0$, $x+4y+z=0$, $2x+y+4z=0$, be a system of equations, then

   a. it is inconsistent

   b. it has only the trivial solution $x=0,\ y=0,\ z=0$

   c. it can be reduced to a single equation and so a solution does not exist

   d. the determinant of the matrix of coefficients is zero

3. Let $M=\begin{pmatrix}1&1&1\\0&1&1\\0&0&1\end{pmatrix}$. The maximum number of linearly independent eigen vectors of M is

   a. 0

   b. 1

   c. 2

   d. 3

4. The shortest and longest distance from the point $(1,\ 2,\ -1)$ to the sphere $x^2+y^2+z^2=24$ is

   a. $\left(\sqrt{14},\sqrt{46}\right)$

   b. $(14,\ 46)$

   c. $\left(\sqrt{24},\sqrt{56}\right)$

   d. $(24,\ 56)$

5. The solution of the given ordinary differential equation $x\frac{d^2y}{dx^2}+\frac{dy}{dx}=0$ is

   a. $y=A\log x+B$

   b. $y=Ae^{\log x}+Bx+C$

   c. $y=Ae^{x}+B\log x+C$

   d. $y=Ae^{x}+Bx^2+C$

6. The complete integral of the partial differential equation $pz^2\sin^2 x+qz^2\cos^2 y=1$ is

   a. $z=3a\cot x+(1-a)\tan y+b$

   b. $z^2=3a^2\cot x+3(1+a)\tan y+b$

   c. $z^3=-3a\cot x+3(1-a)\tan y+b$

   d. $z^4=2a^2\cot x+(1+a)(1-a)\tan y+b$

7. The area between the parabolas $y^2 = 4 - x$ and $y^2 = x$ is given by

a. $\frac{3\sqrt{2}}{16}$

b. $\frac{16\sqrt{3}}{5}$

c. $\frac{5\sqrt{3}}{16}$

d. $\frac{16\sqrt{2}}{3}$

8. The value of the integral $\int_0^a \int_0^b \int_0^c e^{x+y+z}\, dz\, dy\, dx$ is

a. e^{a+b+c}

b. $e^a + e^b + e^c$

c. $(e^a - 1)(e^b - 1)(e^c - 1)$

d. e^{abc}

9. If $\nabla\phi = 2xyz^3\,\vec{i} + x^2z^3\,\vec{j} + 3x^2yz^2\,\vec{k}$, then $\phi(x, y, z) =$

a. $\phi = xyz^2 + c$

b. $\phi = x^3yz^2 + c$

c. $\phi = x^2yz^3 + c$

d. $\phi = x^3yz + c$

10. The only function from the following that is analytic is

a. $F(z) = \mathrm{Re}(z)$

b. $F(z) = \mathrm{Im}(z)$

c. $F(z) = z$

d. $F(z) = \sin z$

11. The value of m so that $2x - x^2 + my^2$ may be harmonic is

a. 0

b. 1

c. 2

d. 3

12. The value of $\int_C \frac{1}{z} dz$, where C is the circle $z = e^{i\theta}$, $0 \le \theta \le \pi$ is,

a. πi

b. $-\pi i$

c. $2\pi i$

d. 0

13. The Region of convergence of the signal $x(n) = \delta(n - k),\ k > 0$ is

a. $z = \infty$

b. $z = 0$

c. Entire z-plane, except at $z = 0$

d. Entire z-plane, except at $z = \infty$

14. The Laplace transform of a signal $X(t)$ is $\frac{4s+1}{s^2+6s+3}$. The initial value $X(0)$ is

a. 0

b. 4

c. 1/6

d. 4/3

15. Given the inverse Fourier transform of $f(s)=\begin{cases} a-|s|, & |s|\le a \\ 0, & |s|>a \end{cases}$ is $\frac{a^2}{2\pi}\left[\frac{\sin\frac{ax}{2}}{\frac{ax}{2}}\right]^2$. The value of $\int_0^\infty\left[\frac{\sin x}{2}\right]^2 dx$ is

a. π

b. $\frac{2\pi}{3}$

c. $\frac{\pi}{2}$

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

16. If $A=[a_{ij}]$ is the coefficient matrix for a system of algebraic equations, then a sufficient condition for convergence of Gauss-Seidel iteration method is

a. A is strictly diagonally dominant

b. $|a_{ii}|=1$

c. $\det(A)\neq 0$

d. $\det(A)>0$

17. Which of the following formula is used to fit a polynomial for interpolation with equally spaced data?

a. Newton's divided difference interpolation formula

b. Lagrange's interpolation formula

c. Newton's forward interpolation formula

d. Least- square formula

18. For applying Simpson's $\frac{1}{3}$ rule, the given interval must be divided into how many number of sub-intervals?

a. odd

b. two

c. even

d. three

19. A discrete random variable X has the probability mass function given by $p(x)=cx,\ x=1,2,3,4,5$. The value of the constant 'c' is

a. 1/5

b. 1/10

c. 1/15

d. 1/20

20. For a Binomial distribution with mean 4 and variance 2, the value of 'n' is

a. 2

b. 4

c. 6

d. 8

PART II — BASIC ENGINEERING AND SCIENCES

(Common to all candidates)

(Answer ALL questions)

21. Speed of the processor chip is measured in
    a. Mbps
    b. GHz
    c. Bits per second
    d. Bytes per second

22. A program that converts Source Code into machine code is called
    a. Assembler
    b. Loader
    c. Compiler
    d. Converter

23. What is the full form of URL?
    a. Uniform Resource Locator
    b. Unicode Random Locator
    c. Unified Real Locator
    d. Uniform Read Locator

24. Which of the following can adsorb larger volume of hydrogen gas?
    a. Finely divided platinum
    b. Colloidal solution of palladium
    c. Small pieces of palladium
    d. A single metal surface of platinum

25. What are the factors that determine an effective collision?
    a. Collision frequency, threshold energy and proper orientation
    b. Translational collision and energy of activation
    c. Proper orientation and steric bulk of the molecule
    d. Threshold energy and proper orientation

26. Which one of the following flows in the internal circuit of a galvanic cell?
    a. atoms
    b. electrons
    c. electricity
    d. ions

27. Which one of the following is not a primary fuel?
    a. petroleum
    b. natural gas
    c. kerosene
    d. coal

28. Which of the following molecules will not display an infrared spectrum?
    a. CO_2
    b. N_2
    c. Benzene
    d. HCCH

29. Which one of the following behaves like an intrinsic semiconductor, at the absolute zero temperature?
    a. Superconductor
    b. Insulator
    c. n-type semiconductor
    d. p-type semiconductor

30. The energy gap (eV) at 300K of the material *GaAs* is
    a. 0.36
    b. 0.85
    c. 1.20
    d. 1.42

31. Which of the following ceramic materials will be used for spark plug insulator?
    a. SnO_2
    b. α-Al_2O_3
    c. TiN
    d. $YBaCuO_7$

32. In unconventional super-conductivity, the pairing interaction is
    a. non-phononic
    b. phononic
    c. photonic
    d. non-excitonic

33. What is the magnetic susceptibility of an ideal super conductor?
    a. 1
    b. –1
    c. 0
    d. infinite

34. The Rayleigh scattering loss, which varies as _____ in a silica fiber.
    a. λ^0
    b. λ^{-2}
    c. λ^{-4}
    d. λ^{-6}

35. What is the near field length N that can be calculated from the relation (if D is the diameter of the transducer and λ is the wavelength of sound in the material)?
    a. $D^2 / 2\lambda$
    b. $D^2 / 4\lambda$
    c. $2D^2 / \lambda$
    d. $4D^2 / \lambda$

36. Which one of the following represents open thermodynamic system?
    a. Manual ice cream freezer
    b. Centrifugal pump
    c. Pressure cooker
    d. Bomb calorimeter

37. In a new temperature scale say $^\circ\rho$, the boiling and freezing points of water at one atmosphere are $100^\circ\ \rho$ and $300^\circ\rho$ respectively. Correlate this scale with the Centigrade scale. The reading of $0^\circ\rho$ on the Centigrade scale is:
    a. 0°C
    b. 50°C
    c. 100°C
    d. 150°C

38. Which of the cross-section of the beam subjected to bending moment is more economical?
    a. Rectangular cross-section
    b. I - cross-section
    c. Circular cross-section
    d. Triangular cross-section

39. The velocity of a particle is given by $V = 4t^3 - 5t^2$. When does the acceleration of the particle becomes zero?
    a. 8.33 s
    b. 0.833 s
    c. 0.0833 s
    d. 1 s

40. What will happen if the frequency of power supply in a pure capacitor is doubled?
    a. The current will also be doubled
    b. The current will reduce to half
    c. The current will remain the same
    d. The current will increase to four-fold

PAPER III

12 – CHEMICAL ENGINEERING

(Answer ALL questions)

41. Tooth paste is an example of ———— fluid.
    a. Newtonian
    b. Power law
    c. Bingham plastic
    d. Pseudo plastic

42. Friction factor in flow through conduit is analogous to ———— in flow around submerged objects.
    a. Shape factor
    b. Roughness factor
    c. Drag coefficient
    d. Shear stress

43. Same force will prevail in model and Prototype under
    a. Conditional similarity
    b. Dynamic similarity
    c. Geometric similarity
    d. Kinematic similarity

44. Inclined manometer is used for
    a. determining high pressure
    b. determining low pressure
    c. determining small differences in pressure
    d. highly viscous liquids

45. 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/m3 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.
    a. 20 cm/s
    b. 4.3 cm/s
    c. 7.16 cm/s
    d. 3.58 cm/s

46. 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
    a. P and Q only
    b. Q and R only
    c. R and S only
    d. P and S only

47. Which of the following minerals is not subjected to magnetic separation method?
    a. Rutile
    b. Galena
    c. Chromite
    d. Siderite

48. Equivalent diameter of a particle is the diameter of the sphere having the same
    a. Ratio of surface to volume as the actual volume
    b. Ratio of volume to surface as the particle
    c. Volume as the particle
    d. Surface as the particle

49. The unit of filter medium resistance is
    a. kg m^{-1}
    b. m^{-1}
    c. m kg^{-1}
    d. kg^{-1}

50. A generalized relation for crushing is $d\left(\frac{P}{m}\right) = -K\frac{d\overline{D}_s}{D_s^n}$ the solution for this equation leads to the Rittengers law for 'n' equal to

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

51. The Value of Gibbs free energy change at equilibrium condition is

a. Greater than one
b. Less than one
c. Equal to one
d. Equal to zero

52. Match the technologies in Group 1 with the entries in Group 2 :

Group – 1	Group 2
(P) Urea manufacture	(I) Microencapsulation
(Q) Coal gasification	(II) Ultra-low sulphur diesel
(R) Controlled release of chemicals	(III) Shale oil
(S) Deep hydro-desulphurization	(IV) Prilling tower
	(V) Gas hydrates
	(VI) Gas – solid non-catalytic reaction

a. P-I, Q-V, R -II, S-VI
b. P-IV, Q-VI, R-I, S-II
c. P-IV, Q-I, R-III, S-II
d. P-V, Q-VI, R-IV, S-II

53. An arbitrary scale used in sugar industry is

a. °API
b. ° Baume
c. ° Brix
d. ° Twaddle

54. A typical example of an exothermic reversible reaction conducted at high pressures in industry is

a. dehydration of ethanol,
b. methanol synthesis,
c. reformation of ethane,
d. polymerisation of ethylene,

55. Aniline point test of an oil qualitatively indicates

a. Naphthalene content
b. Paraffin content
c. Aromatic content
d. Olefin Content

56. What is the Temperature at which °C is equal to °F?

a. 0
b. 32
c. – 40
d. – 32

57. $CaCO_3$ Contains _____ of Calcium.

a. 12%
b. 35%
c. 60%
d. 40%

58. What mass of 75% pure $CaCO_3$ will be required to neutralize 50 ml of 0.5M HCL solution according to following reaction?

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

a. 1.67 g
b. 3.35 g
c. 4.23 g
d. 5.05 g

59. What is the heat capacity of $Na_2SO_4.10H_2O$ at room temperature using Kopp's rule? (The atomic heat capacities of elements (J/g-atomK) are 26.04 for Na, 22.6 for S, 16.8 for O and 9.6 for H)

a. 325.4
b. 501.9
c. 65.44
d. 177.90

60. In the process of producing caustic (NaOH), 4000 kg/h of a solution containing 10 wt% NaOH is evaporated in the first evaporator, giving a 20% NaOH solution. This is then fed into a second evaporator which gives a product of 50% NaOH. The amount of water removed from each evaporator is

a. 2000 kg, 1200 kg
b. 1000 kg, 1200 kg
c. 2000 kg , 1000 kg
d. 1200 kg, 600 kg

61. The change in the Gibbs free energy for the vapourisation of a pure substance is

a. Positive
b. Negative
c. Zero
d. May be positive or negative

62. Assuming that CO_2 obeys the perfect gas law, the density of CO_2 in kg/m^3 at 536 K and 202.6 kPa is

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

63. A three stage compressor is used to compress a gas at 1 bar to a final pressure of 125 bar. For minimum work, the pressure ratios in each stage should be

a. 25
b. 5
c. 41.67
d. 26.24

64. The ordinary vapour compression cycle for refrigeration is less efficient than the Carnot cycle , because in the former,

a. Evaporation process is non-isothermal
b. A two–phase mixture is to be compressed
c. Vapour leaving the compressor is superheated
d. Expansion process results in liquefaction

65. A cyclic engine exchanges heat with two reservoirs maintained at 100° C 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

66. An irreversible, homogeneous reaction A→products, has the rate expression :

$$\text{Rate} = \frac{2C_A^2 + 0.1C_A}{1 + 50\,C_A}$$

where C is the concentration of A.

CA varies in the range 0.5 – 50 mol/m^3.

For very high concentration of A, the reaction order tends to :

a. 0
b. 1
c. 1.5
d. 2

67. A gaseous reaction A→ 2B + C takes place isothermally in a constant pressure reactor. Starting with a gaseous mixture containing 50% A (rest inerts), the ratio of final to initial volume is found to be 1.6. The percentage conversion of A is

a. 30
b. 50
c. 60
d. 74

68. A reaction A→B is to be conducted in two CSTR in series. The steady state conversion desired is Xf The reaction rate as a function of conversion is given by r = –1/(1+X). If the feed contains no B, then the conversion in the first reactor that minimizes the total volume of the two reactors is

a. $1–X_f$
b. $0.2\ X_f$
c. $0.5\ X_f$
d. $0.5\ (1–X_f)$

69. Catalyst pellets have a density of 2.0 g/cc. If the specific surface area is 75 m^2/g and the average pore diameter is 8×10^{-7} cm. What is the porosity of the catalyst?

a. 0.4
b. 0.5
c. 0.3
d. 0.7

70. What is the Knudsen diffusion coefficient for cumene at 510° C through the pores of a catalyst of porosity 0.51 and density 1.14 gm/cm^3 . The specific surface area is 342 m^2/gm

a. 2.46 cm^2/sec
b. 6.46×10^{-3} cm^2/sec
c. 8.46×10^{-3} cm^2/sec
d. 1.05×10^{-4} cm^2/sec

71. For true counter current flow in a shell and tube heat exchanger, the value of correction factor FT is

a. 1
b. 0.75
c. 0.95
d. 0.75 – 0.95

72. In a completely opaque medium, if 50% of the incident monochromatic radiation is absorbed, then which of the following statements are **CORRECT**?

(P) 50% of the incident radiation is reflected
(Q) 25% of the incident radiation is reflected
(R) 25% of the incident radiation is transmitted
(S) No incident radiation is transmitted

a. P and S only
b. Q and R only
c. P and Q only
d. R and S only

73. In a furnace the wall thickness is 60 cm and is 100 cm wide by 150 cm height made of material with thermal conductivity 0.4 w/mk. The temperature inside and outside are 1000° and 4° C respectively.

The thermal resistance is

a. 1 K/W
b. 2 K/W
c. 18 K/W
d. 15 K/W

74. Sun's surface at 5800 K emits radiation at a wavelength of $0.5\,\mu$. A furnace at 300°C will emit through a small opening, radiation at a wavelength of nearly

a. $10\,\mu$
b. $5\,\mu$
c. $0.25\,\mu$
d. $0.025\,\mu$

75. A chemical having specific heat of 3.3 kJ/kg K flowing at the rate of 20000 kg/h enters a parallel flow heat exchanger at 120°C. The flow rate of cooling water is 50000 kg/h with an inlet temperature of 20°C. The overall heat transfer coefficient is 1050 W/m²K. The heat transfer area is 10 m² Take for water, specific heat = 4.186 kJ/kgK. Effectiveness of the heat exchanger will be

a. 0.2
b. 0.3
c. 0.4
d. 0.6

76. Which of the following happens in the use of Raschig rings in place of crushed stones as packing in packed beds (other things being same)?

a. increases pressure drop, increases surface area
b. increases pressure drop, decreases surface area
c. decreases pressure drop, increases surface area
d. decreases pressure drop, decreases surface area

77. Kirkbride equation is used for determining the

a. Rmin
b. Nmin
c. Nopt
d. Feed tray location

78. In a triple effect backward feed evaporator, the pressure of vapor space in each of the effect is related by (Hint: Use steam entry as the I effect)

a. P1=P2=P3
b. P1>P2>P3
c. P1<P2<P3
d. cannot be said

79. A mixture of toluene (40%) and benzene (60%) is fed to the Distillation column; recovery of benzene is 20% at the top, what is the ratio of flow rate of benzene from Distillate to the bottoms? (Based on 1000 Kg of feed)?

a. 0.6
b. 0.2
c. 0.25
d. 0.4

80. A spherical naphthalene ball of 2mm diameter is subliming very slowly in stagnant air at 25°C. The change in the size of the ball during the sublimation can be neglected. The diffusivity of naphthalene in air at 25°C is 1.1×10^{-6} m²/s. The value of mass transfer coefficient is B × 10^{-3} m/s, where B (up to one decimal place) is

a. 1.1
b. 1.2
c. 1.3
d. 1.4

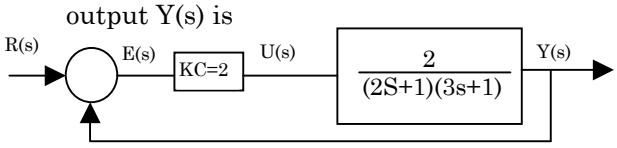
81. The inverse Laplace transform of $\frac{1}{2s^2+3s+1}$ is

a. $e^{-t/2}-e^{-t}$
b. $2e^{-t/2}-e^{-t}$
c. $e^{-t}-2e^{-t/2}$
d. $e^{-t}-e^{-t/2}$

82. The characteristic equation of a closed loop system using a proportional controller with gain K_C is $12s^3 + 19\ s^2 + 8s + 1 + K_C = 0$. At the onset of instability, the value of K_C is

a. 35/3
b. 10
c. 25/3
d. 20/3

83. The block diagram for a control system is shown below: for a unit step change in the set point, R(s), the steady state offset in the output Y(s) is



a. 0.2
b. 0.3
c. 0.4
d. 0.5

84. Given the characteristic equation below, what is the number of roots which will be located to the right of the imaginary axis
$s^4+5s^3-s^2-17s+12 = 0$?
a. One
b. Two
c. Three
d. Zero

85. Given the process transfer function $G_P = 4/(\tau s+1)^2$ and the disturbance transfer function $G_d = 2/(\tau s+1)$, what is the correct transfer function for the Feed Forward Controller for perfect disturbance rejection?
a. $-2(\tau s+1)$
b. -1
c. $-0.5(\tau s+1)$
d. $-(\tau s+1)^2$

86. Given the process transfer function $G_P = 20/(s-2)$, and controller transfer function $G_C = K_C$, and assuming the transfer function of all other elements in the control loop are unity, what is the range of K_C for which the closed loop response will be stable?
a. $K_C < 1/10$
b. $K_C < 1/100$
c. $1/100 < K_C < 1/10$
d. $K_C > 1/10$

87. The value of ultimate period of oscillation P_u is 3 minutes, and that of the ultimate controller gain K_{cu} is 2. What is the correct set of tuning parameters (controller gain K_C, the derivative time constant τ_D in minutes, and the integral time constant τ_1 in minutes) for a PID controller using Zielger-Nichols controller settings?
a. $K_C = 1.1$; $\tau_1 = 2.1$; $\tau_D = 1.31$
b. $K_C = 1.5$; $\tau_1 = 1.8$; $\tau_D = 0.51$
c. $K_C = 15$; $\tau_1 = 1.8$; $\tau_D = 0.51$
d. $K_C = 1.2$; $\tau_1 = 1.5$; $\tau_D = 0.38$

88. A system has poles at 0.01 Hz, 1 Hz and 80 Hz, zeros at 5 Hz, 100 Hz, and 200 Hz. The approximate phase of the system responds at 20 Hz is
a. $+90^\circ$
b. -90°
c. $+180^\circ$
d. -180°

89. The numerical technique used to solve simultaneous equation is
a. Newton's method
b. Regression method
c. Intersection method
d. Gauss Elimination method

90. The Antoine constant for the component is given by A = 16.678; B = 3640.2; C = 219.61. The pressure (kPa) for the temperature 373 K is
a. 100
b. 200
c. 37.6
d. 50.8

91. Which one of the following adsorbents is preferred for adsorbing components from aqueous solutions and moist gases because of its poor affinity with water?
a. Activated carbon
b. Silica Gel
c. Activated alumina
d. Molecular sieve zeolites

92. Favourable adsorption isotherms are those
   a. Which are linear and pass through the origin
   b. Which are concave towards the solid-concentration axis throughout
   c. Which are concave towards the fluid-concentration axis throughout
   d. Which possess one or more points of inflection

93. Mass transfer zone in fixed bed adsorber is
   a. The portion of the bed with constant adsorbate concentration
   b. The portion of the bed saturated with adsorbate
   c. The portion of the bed in which concentration changes from feed concentration to zero
   d. The zone that follows the unused bed and saturated bed

94. Adsorption of acetone from aqueous solution on activated carbon can be represented by the Langmuir equation $q = \frac{0.190\,C}{1 + 0.146C}$ where q is the adsorbate loading mol/kg, C = solute concentration in aqueous solution mol/m^3. The maximum adsorbate loading in kg acetone/kg carbon is
   a. 0.0755
   b. 1.3014
   c. 0.1658
   d. 0.0096

95. Rancidity of oil can be reduced by
   a. Decoloration
   b. Hydrogenation
   c. Oxidation
   d. purification

96. Which of the following is not a method of source reduction?
   a. Recycling
   b. Municipal composting
   c. Incineration
   d. Making package that weight less

97. The major contributor of carbon monoxide is
   a. Motor vehicle
   b. Industrial processes
   c. Stationary fuel combustion
   d. Domestic usage

98. What is the value of BOD of industrial sewage in kg/day, given population equivalent as 6000 persons?
   a. 480
   b. 160
   c. 270
   d. 100

99. The aerobic decomposition of sulfurous organic matter gives
   a. Nitrites and water
   b. Carbon dioxide and water
   c. Sulfates and water
   d. Nitrogen and Ammonia

100. Which of the following is an example of attached growth reactor?
   a. Trickling filter
   b. Up-flow anaerobic sludge reactor
   c. Lagoon
   d. Aerobic digestion