2004

PHYSICS

1. Which one of the following represents the correct dimensions of the coefficient of viscosity?
   (a) $[ML^{-1}T^{-2}]$ (b) $[MLT^{-1}]$
   (c) $[ML^{-1}T^{-1}]$ (d) $[ML^{-2}T^{-2}]$

2. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to
   (a) x^2 (b) e^x
   (c) x (d) $\log_e x$

3. A ball is released from the top of a tower of height h metre. It takes T second to reach the ground. What is the position of the ball in T/3 s?
   (a) h/9 m from the ground (b) 7h/9 m from the ground
   (c) 8h/9 m from the ground (d) 17h/18 m from the ground

4. If A x B = B x A, then the angle between A and B is
   (a) π (b) π/3
   (c) π/2 (d) π/4

5. A projectile can have the same range R for two angles of projection. If T_1 and T_2 are the times of flights in the two cases, then the product of the two times of flights is directly proportional to
   (a) $1/R^2$ (b) 1/R
   (c) R (d) R^2

6. Which of the following statements is false for a particle moving in a circle with a constant angular speed?
   (a) The velocity vector is tangent to the circle
   (b) The acceleration vector is tangent to the circle
   (c) The acceleration vector points to the centre of the circle
   (d) The velocity and acceleration vectors are perpendicular to each other

7. An automobile travelling with a speed of 60 km/h, can brake to stop within a distance of 20 m. If the car is going twice as fast i.e., 120 km/h, the stopping distance will be
   (a) 20 m (b) 40 m
   (c) 60 m (d) 80m

8. A machine gun fires a bullet of mass 40 g with a velocity 1200 ms^{-1}. The man holding it, can exert a maximum force of 144 N on the gun. How many bullets can be fire per second at the most?
   (a) One (b) Four
   (c) Two (d) Three

9. Two masses m_1 = 5 kg and m_2 = 4.8 kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses when lift is free to move? ($g = 9.8\ m/s^2$)
   (a) $0.2\ m/s^2$ (b) $9.8\ m/s^2$
   (c) $5\ m/s^2$ (d) $4.8\ m/s^2$

10. A uniform chain of length 2 m is kept on a table such that a length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg. What is the work done in pulling the entire chain on the table?
   (a) 7.2 J (b) 3.6 J
   (c) 120 J (d) 1200 J

11. A block rests on a rough inclined plane making an angle of 30º with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, the mass of the block (in kg) is
   (take $g = 10\ m/s^2$)
   (a) 2.0 (b) 4.0
   (c) 1.6 (d) 2.5

12. A force F = (5i+3j+2k) N is applied over a particle which displaces it from its origin to the point r = (2i-j) m. The work done on the particle in joules is
   (a) - 7 (b) + 7
   (c) + 10 (d) + 13

13. A body of mass m accelerates uniformly from rest to V_1 in time t_1. The instantaneous power delivered to the body as a function of time t is
   (a) mv_1t/t_1 (b) $mv^2{}_1t/t^2{}_1$
   (c) mv_1t^2/t_1 (d) $mv^2{}_1t/t_1$

14. A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle taken place in a plane, it follows that
   (a) its velocity is constant (b) its acceleration is constant
   (c) its kinetic energy is constant (d) it moves in a straight line

15. A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same which one of the following will not be affected?
   (a) Moment of inertia (b) Angular momentum
   (c) Angular velocity (d) Rotational kinetic energy

16. A ball is thrown from a point with a speed v_0 at an angle of projection θ. From the same point and at the same instant, a person starts running with a constant speed $v_0/2$ to catch the ball. Will the person be able to catch the ball? If yes, what should be the angle of projection?
   (a) Yes, 60º (b) Yes, 30º
   (c) No (d) Yes, 45º

17. One solid sphere A and another hollow sphere B are of same mass and same outer radii. Their moment of inertia about their diameters are respectively I_A and I_B such that
(a) $I_A = I_B$ (b) $I_A > I_B$
(c) $I_A < I_B$ (d) $I_A/I_B = d_A/d_B$
Where d_A and d_B are their densities.

18. A satellite of mass m revolves around the earth of radius R at a height x from it surface. If g is the acceleration due to gravity on the surface of the earth, the orbital speed of the satellite is
(a) gx (b) gR/R-x
(c) $gR^2/R + x$ (d) $(gR^2/R + x)^{1/2}$

19. The time period of an earth satellite in circular orbit is independent of
(a) the mass of the satellite
(b) radius of the orbit
(c) both the ass and radius of the orbit
(d) neither the mass of the satellite nor the radius of its orbit

20. If g is the acceleration due to gravity on the earth's surface, the gain in the potential energy of an object of mass m raised from the surface of the earth to a height equal to the radius R of the earth, is
(a) 2mgR (b) $\frac{1}{2}$ mgR
(c) $\frac{1}{4}$ mgR (d) mgR

21. Suppose the gravitational force varies inversely as the nth power of distance. Then the time period of a planet in circular orbit of radius R around the sun will be proportional to
(a) $R^{(n+1/2)}$ (b) $R^{(n-1/2)}$
(c) R^n (d) $R^{(n-2/2)}$

22. A wire fixed at the upper end stretches by length l by applying a force F. The work done in stretching is
(a) $\frac{F}{2l}$ (b) Fl
(c) 2Fl (d) $\frac{Fl}{2}$

23. Spherical balls of radius R are falling in a viscous fluid of viscosity η with a velocity v. The retarding viscous force acting on the spherical ball is
(a) directly proportional to R but inversely proportional to v
(b) directly proportional to both radius R and velocity v
(c) inversely proportional to both radius R and velocity v
(d) inversely proportional to R but directly proportional to velocity v

24. If two soap bubbles of different radii are connected by a tube
(a) air flows from the bigger bubble to the smaller bubble till the sizes become equal
(b) air flows from bigger bubble to the smaller bubble till the sizes are interchanged
(c) air flows from the smaller bubble to the bigger
(d) there is no flow of air

25. The bob of a simple pendulum executes simple harmonic motion in water with a period t, while the period of oscillation of the bob is t_0 in air. Neglecting frictional force of water and given that the density of the bob is (4/3) x 1000 kg/m^3. What relationship between t and t_0 is true?
    (a) $t = t_0$ (b) $t = t_0/2$
    (c) $t = 2t_0$ (d) $t = 4t_0$

26. A particle at the end of a spring executes simple harmonic motion with a period t_1, while the corresponding period for another spring is t_2. If the period of oscillation with two springs in series is T, then
    (a) $T = t_1 + t_2$ (b) $T^2 = t^2_1 + t^2_2$
    (c) $T^{-1} = t^{-1}_1 + t^{-1}_2$ (d) $T^{-2} = t^{-2}_1 + t^{-2}_2$

27. The total energy of a particle, executing simple harmonic motion is
    (a) x (b) x^2
    (c) independent of x (d) $x^{1/2}$

28. The displacement y of a particle in a medium can be expressed as $y = 10^{-6} \sin (100t + 20x + \frac{\pi}{4})$ m, where t is in second and x in metre. The speed of the wave is
    (a) 2000 m/s (b) 5 m/s
    (c) 20 m/s (d) 5π m/s

29. A particle of mass m is attached to a spring (of spring constant k) and has a natural angular frequency ω_0. An external force F(t) proportional to cos ωt ($\omega \neq \omega_0$) is applied to the oscillator. The time displacement of the oscillator will be proportional to
    (a) $m/\omega^2_0 - \omega^2$ (b) $1/m(\omega^2_0 - \omega^2)$
    (c) $1/m(\omega^2_0 + \omega^2)$ (d) $m/\omega^2_0 + \omega^2$

30. In forced oscillation of a particle, the amplitude is maximum for a frequency ω_1 of the force, while the energy is maximum for a frequency ω_2 of the force, then
    (a) $\omega_1 = \omega_2$
    (b) $\omega_1 > \omega_2$
    (c) $\omega_1 < \omega_2$ when damping is small and $\omega_1 > \omega_2$ when damping is large
    (d) $\omega_1 < \omega_2$

CHEMISTRY

31. Which of the following sets of quantum numbers is correct for an electron in 4f orbital?
    (a) n = 4, l = 3, m = + 4, s = + 1/2 (b) n = 4, l = 4, m = - 4, s = - 1/2
    (c) n = 4, l = 3, m = + 1, s = + 1/2 (d) n = 3, l = 2, m = -2, s = + 1/2

32. Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, l = 1 and 2 are, respectively
    (a) 12 and 4 (b) 12 and 5
    (c) 16 and 4 (d) 16 and 5

33. Which one of the following ions has the highest value of ionic radius?
    (a) Li^+ (b) B^{3+}
    (c) O^{2-} (d) F^-

34. The wavelength of the radiation emitted, when in a hydrogen atom electron falls from infinity to stationary state 1, would be (Rydberg constant = $1.097 \times 10^7\ m^{-1}$)
    (a) 91 nm (b) 192 nm
    (c) 406 nm (d) 9.1×10^{-8} nm

35. The correct order of bond angles (smallest first) in H_2S, NH_3, BF_3 and SiH_4 is
    (a) $H_2S < SiH_4 < NH_3 < BF_3$ (b) $NH_3 < H_2S < SiH_4 < BF_3$
    (c) $H_2S < NH_3 < SiH_4 < BF_3$ (d) $H_2S < NH_3 < BF_3 < SiH_4$

36. Which one of the following sets of ions represents the collection of isoelectronic species?
    (At. Nos. F = 9, Cl = 17, Na = 11, Mg = 12, Al = 13, K = 19, Ca = 20, Sc = 21)
    (a) K^+, Ca^{2+}, Sc^{3+}, Cl^- (b) Na^+, Ca^{2+}, Sc^{3+}, F^-
    (c) K^+, Cl^-, Mg^{2+}, Sc^{3+} (d) Na^+, Mg^{2+}, Al^{3+}, Cl^-

37. Among Al_2O_3, SiO_2, P_2O_3 and SO_2, the correct order of acid strength is
    (a) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$ (b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
    (c) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$ (d) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$

38. The bond order in NO is 2.5 while that in NO^+ is 3. Which of the following statements is true for these two species?
    (a) Bond length in NO^+ is greater than in NO
    (b) Bond length in NO is greater than in NO^+
    (c) Bond length in NO^+ is equal to that in NO
    (d) Bond length is unpredictable

39. The formation of the oxide ion O^{2-} (g) requires first an exothermic and then an endothermic step as shown below
$O(g) + e^- = O^-(g)$; ΔH^o = - 142 kJ mol^{-1}
$O^-(g)^- + e^- = O^2(g)$; ΔH^o = 844 kJ mol^{-1}
This is because
(a) oxygen is more electronegative
(b) oxygen has high electron affinity
(c) O^- ion will tend to resist the addition of another electron
(d) O^- ion has comparatively larger size than oxygen atom

40. The states of hybridisation of boron and oxygen atoms in boric acid (H_3BO_3) are respectively
(a) sp^2 and sp^2 (b) sp^2 and sp^3
(c) sp^3 and sp^2 (d) sp^3 and sp^3

41. Which one of the following has the regular tetrahedral structure?
(At. Nos. B = 5, S = 16, Ni = 28, Xe = 54)
(a) XeF_4 (b) SF_4
(c) BF^-_4 (d) $[Ni(CN)_4]^{2-}$

42. Of the following outer electronic configurations of atoms, the highest oxidation state is achieved by which one of them?
(a) $(n-1)d^8ns^2$ (b) $(n-1)d^5ns^1$
(c) $(n-1)d^3ns^2$ (d) $(n-1)d^5ns^2$

43. As the temperature is raised from 20ºC to 40ºC, the average kinetic energy of neon atoms changes by a factor of which of the following?
(a) 1/2 (b) $\sqrt{313/293}$
(c) 313/293 (d) 2

44. The maximum number of 90º angles between bond pair-bond pair of electrons is observed in
(a) dsp^3 hybridisation (b) sp^3d^2 hybridisation
(c) dsp^2 hybridisation (d) sp^3d hybridisation

45. Which one of the following aqueous solutions will exhibit highest boiling point?
(a) 0.01 M Na_2SO_4 (b) 0.01 M KNO_3
(c) 0.015 M urea (d) 0.015 M glucose

46. Which among the following factors is the most important in making fluorine the strongest oxidising agent?
(a) Electron affinity (b) Ionisation enthalpy
(c) Hydration enthalpy (d) Bond dissociation energy

47. In van der Waals' equation of state of the gas law, the constant 'b' is a measure of
    (a) intermolecular repulsions
    (b) intermolecular attraction
    (c) volume occupied by the molecules
    (d) intermolecular collisions per unit volume

48. The conjugate base of $H_2PO^-_4$ is
    (a) PO^{3-}_4 (b) P_2O_5
    (c) H_3PO_4 (d) HPO^{2-}_4

49. 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of urea solution is (Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1})
    (a) 0.001 M (b) 0.01 M
    (c) 0.02 M (d) 0.1 M

50. To neutralise completely 20 mL of 0.1M aqueous solution of phosphorous acid (H_3PO_3), the volume of 0.1M aqueous KOH solution required is
    (a) 10 mL (b) 20 mL
    (c) 40 mL (d) 60 mL

51. For which of the following parameters the structural isomers C_2H_5OH and CH_3OCH_3 would be expected to have the same values? (Assume ideal behaviour)
    (a) Heat of vaporisation
    (b) Vapour pressure at the same temperature
    (c) Boiling points
    (d) Gaseous densities at the same temperature and pressure

52. Which of the following liquid pairs shows positive deviation from Raoult's law?
    (a) Water – hydrochloric acid (b) Benzene – methanol
    (c) Water – nitric acid (d) Acetone – chloroform

53. Which of the following statement is false?
    (a) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction
    (b) The osmotic pressure (π) of a solution is given by the equation $\pi = MRT$, where M is the molarity of the solution
    (c) The correct order of osmotic pressure for 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ sucrose
    (d) Two sucrose solutions of same molality prepared in different solvent will have the same freezing point depression

54. What type of crystal defect is indicated in the diagram below?
    Na^+, Cl^-, Na^+, Cl^-, Na^+, Cl^-
    Cl^- Cl^- Na^+ Na^+
    Na^+ Cl^- Cl^-, Na^+ Cl^-
    Cl^- Na^+ Cl^- Na^+ Na^+
    (a) Frenkel defect (b) Schottky defect
    (c) Interstitial defect (d) Frenkel and Schottky defects

55. An ideal gas expands in volume from 1 x 10^{-3} m^3 to 1 x 10^{-2} m^3 at 300 K against a constant pressure of 1 x 10^5 Nm^{-2}. The work done is
(a) – 900 J (b) -900 kJ
(c) 270 kJ (d) 900 kJ

56. In a hydrogen-oxygen fuel cell, combustion of hydrogen occurs to
(a) generate heat
(b) create potential difference between the two electrodes
(c) produce high purity water
(d) remove adsorbed oxygen from electrode surfaces

57. In a first order reaction, the concentration of the reactant, decreases from 0.8 M to 0.4 M in 15 min. The time taken for the concentration to change from 0.1 M to 0.025 M is
(a) 30 min (b) 15 min
(c) 7.5 min (d) 60 min

58. What is the equilibrium expression for the reaction
$P_4(s) + 5O_2$ (g) $P_4O_{10}(s)$?
(a) $K_c = [P_4O_{10}]/[P_4][O_2]^5$ (b) $K_c = [P_4O_{10}]/5[P_4]\ [O_2]$
(c) $K_c = [O_2]^5$ (d) $K_c = 1/[O_2]^5$

59. For the reaction,
$CO(g) + Cl_2$ (g) $COCl_2$ (g), the K_p / K_c is equal to
(a) 1/RT (b) RT
(c) $\sqrt{RT}$ (d) 1.0

60. The equilibrium constant for the reaction $N_2(g) + O_2(g)$ 2NO(g) at temperature T is 4 x 10^{-4}. The value of K_c for the reaction NO(g) $\frac{1}{2}$ $N_2(g)$ + $\frac{1}{2}$ $O_2(g)$ at the same temperature is
(a) 2.5 x 10^2 (b) 50
(c) 4 x 10^{-4} (d) 0.02

MATHEMATICS

61. Let R = {(1,3), (4,2), (2,4) , (2,3), (3,1)} be a relation on the set A = {1, 2, 3, 4}. The relation R is
    (a) a function
    (b) transitive
    (c) not symmetric
    (d) reflexive

62. The range of the function f(x) = $^{7-x}P_{x-3}$ is
    (a) {1, 2, 3}
    (b) {1, 2, 3, 4, 5, 6}
    (c) {1, 2, 3, 4}
    (d) {1, 2, 3, 4, 5}

63. Let z, w be complex numbers such that z + iw = 0 and arg (zw) = π. Then, arg (z) equals
    (a) $\frac{\pi}{4}$
    (b) $\frac{\pi}{2}$
    (c) $\frac{3\pi}{4}$
    (d) $\frac{5\pi}{4}$

64. If z = x-iy and $z^{1/3}$ = p + iq, then (x/p + y/q)/(p^2 + q^2) is equal to
    (a) 1
    (b) -1
    (c) 2
    (d) -2

65. If $|z^2 - 1| = |z|^2 + 1$, then z lies on
    (a) the real axis
    (b) the imaginary axis
    (c) a circle
    (d) an ellipse

66. Let A = . The only correct statement about the matrix A is
    (a) A is a zero matrix
    (b) A = (-1)/, where / is a unit matrix
    (c) A^{-1} does not exist
    (d) A^2 = /

67. Let A = and 10 B = . If B is the inverse of matrix A, then a is
    (a) -2
    (b) 1
    (c) 2
    (d) 5

68. If $a_1, a_2, a_3, \ldots, a_n, \ldots$ are in GP, then the value of the determinant
    (a) 0
    (b) 1
    (c) 2
    (d) -2

69. Let two numbers have arithmetic mean 9 and geometric mean 4. Then, these numbers are the roots of the quadratic equation
    (a) $x^2 + 18x + 16 = 0$
    (b) $x^2 - 18x + 16 = 0$
    (c) $x^2 + 18x - 16 = 0$
    (d) $x^2 - 18x - 16 = 0$

70. If (1-p) is a root of quadratic equation $x^2 + px + (1-p) = 0$, then its roots are
    (a) 0, 1
    (b) -1, 1
    (c) 0, -1
    (d) -1, 2

71. Let S(K) = 1+3+5+…+(2K-1) = 3 + K^2. Then, which of the following is true?
    (a) S(1) is correct
    (b) S(K) S(K+1)
    (c) S(K) S(K+1)
    (d) Principle of mathematical induction can be used to prove the formula

72. How many ways are there to arrange the letters in the word GARDEN with the vowels in alphabetical order?
    (a) 120 (b) 240
    (c) 360 (d) 480

73. The number of ways of distributing 8 identical balls in 3 distinct boxes, so that none of the boxes is empty, is
    (a) 5 (b) 21
    (c) 3^8 (d) $^8C_3$

74. If one root of the equation x^2 + px + 12 = 0 is 4, while the equation x^2 + px + q = 0 has equal roots, then the value of 'q' is
    (a) $\frac{49}{4}$ (b) 12
    (c) 3 (d) 4

75. The coefficient of the middle term in the binomial expansion in powers of x of $(1+ax)^4$ and of $(1-ax)^6$ is the same, if a equals
    (a) $-\frac{5}{3}$ (b) $\frac{10}{3}$
    (c) $-\frac{3}{10}$ (d) $\frac{3}{5}$

76. The coefficient of x^n in the expansion of $(1+x)(1-x)^n$ is
    (a) (n-1) (b) $(-1)^n$ (1-n)
    (c) $(-1)^{n-1}$ $(n-1)^2$ (d) $(-1)^{n-1}$ n

77. If $S_n = 1/{}^nC_r$ and $t_n = r/{}^nC_r$, then t_n/S_n is equal to
    (a) $\frac{n}{2}$ (b) $\frac{n}{2} - 1$
    (c) n – 1 (d) $\frac{2n-1}{2}$

78. Let T_r be the rth term of an AP whose first term is a and common difference is d. If for some positive integers m, n, m ≠ n $_1T_m = \frac{1}{n}$ and $T_n = \frac{1}{m}$, then a – d equals
    (a) 0 (b) 1
    (c) $\frac{1}{mn}$ (d) $\frac{1}{m} + \frac{1}{n}$

79. The sum of the first n terms of the series 1^2 + 2.2^2 + 3^2 + 2.4^2 + 5^2 + 2.6^2 + … is $n(n+1)^2/2$, when n is even, When n is odd, the sum is
    (a) $\frac{3n\,(n+1)}{2}$ (b) n^2 (n + 1) /2
    (c) $n(n+1)^2$ / 4 (d) $[n(n+1)/2]^2$

80. The sum of series $\frac{1}{2!} + \frac{1}{4!} + \frac{1}{6!} + \ldots$ is
(a) $(e^2 - 1) / 2$ (b) $(e - 1)^2/2e$
(c) $(e^2 - 1) / 2e$ (d) $(e^2 - 2) / e$

81. Let α, β be such that $\pi < \alpha - \beta < 3\pi$. If $\sin\alpha + \sin\beta = -\frac{21}{65}$ and $\cos\alpha + \cos\beta = -\frac{21}{65}$ and $\cos\alpha + \cos\beta = -\frac{27}{65}$, then the value of $\cos(\alpha-\beta/2)$ is
(a) $-\frac{3}{\sqrt{130}}$ (b) $\frac{3}{\sqrt{130}}$
(c) $\frac{6}{165}$ (d) $-\frac{6}{165}$

82. If u = then the difference between the maximum and minimum value of u^2 is given by
(a) $2(a^2 + b^2)$ (b) 2
(c) $(a + b)^2$ (d) $(a - b)^2$

83. The sides of a triangle are sin a, cos a and $\sqrt{1 + \sin a \cos a}$ for some $0 < a < \frac{\pi}{2}$. Then, the greatest angle of the triangle is
(a) 60º (b) 90º
(c) 120º (d) 150º

84. A person standing on the bank of a river, observes that the angle of elevation of the top of a tree on the opposite bank of the river is 60º and when he retires 40 m away from the tree, the angle of elevation becomes 30º. The breadth of the river is
(a) 20 m (b) 30 m
(c) 40 m (d) 60 m

85. If f : R → S, defined by $f(x) = \sin x - \sqrt{3}\cos x + 1$, is onto, then the interval of S is
(a) [0, 3] (b) [-1, 1]
(c) [0, 1] (d) [-1, 3]

86. The graph of the function y = f(x) is symmetrical about the line x = 2, then
(a) f(x + 2) = f(x – 2) (b) f(2 + x) = f(2 – x)
(c) f(x) = f(-x) (d) f(x) = -f(-x)

87. The domain of the function $f(x) = \sin^{-1}(x - 3)/$ is
(a) [2, 3] (b) [2, 3]
(c) [1, 2] (d) [1, 2]

88. If $(1 + a/x + b/x^2)^{2x} = e^2$, then the values of a and b are
(a) a ϵ R, b ϵ R (b) a = 1, b ϵ R
(c) a ϵ R, b = 2 (d) a = 1, b = 2

89. Let $f(x) = \frac{1-\tan x}{4x-\pi}$, $x \neq \frac{\pi}{4}$, x ϵ [0, π/2]. If f(x) is continuous in [0, π/2], then f(π/4) is
(a) 1 (b) 1/2
(c) -1/2 (d) -1

90. If $x = e^{y+}$

(a) $\frac{x}{1+x}$ (b) $\frac{1}{x}$

(c) $\frac{1-x}{x}$ (d) $\frac{1+x}{x}$