PHYSICS

1. 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 proportional to
   (a) R^2
   (b) $1/R^2$
   (c) $1/R$
   (d) R

2. An annular ring with inner and outer radii R_1 and R_2 is rolling without slipping with a uniform angular speed. The ratio of the forces experienced by the two particles situated on the inner and outer parts of the ring F_1/F_2 is
   (a) R_2/R_1
   (b) $(R_1/R_2)^2$
   (c) 1
   (d) R_1/R_2

3. A smooth block is rest on a 45^0 incline and then slides a distance d. The time taken to slide is n times as much to slide on rough incline than on a smooth incline. The coefficient of friction is

   (a) $\mu_k = 1 - \dfrac{1}{n^2}$
   (b) $\mu_k = \sqrt{1 - \dfrac{1}{n^2}}$

   (a) $\mu_s = 1 - \dfrac{1}{n^2}$
   (d) $\mu_s = \sqrt{1 - \dfrac{1}{n^2}}$

4. The upper half of an inclined plane with inclination ϕ is perfectly smooth, while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom, if the coefficient of friction for the lower half is given by
   (a) 2 sin ϕ
   (b) 2 cos ϕ
   (c) 2 tan ϕ
   (d) tan ϕ

5. A bullet fired into a fixed target loses half of its velocity after penetrating 3 cm. How much further it will penetrate before coming to rest, assuming that it faces constant resistance to motion?
   (a) 3.0 cm
   (b) 2.0 cm
   (c) 1.5 cm
   (d) 1.0 cm

6. Out of the following pairs, which one does not have identical dimensions?
   (a) Angular momentum and Planck's constant
   (b) Impulse and momentum
   (c) Moment of inertia and moment of a force
   (d) Work and torque

7. The relation between time t and distance x is $t = ax^2 + bx$, where a and b are constants. The acceleration is
   (a) $-2abv^2$
   (b) $2bv^3$
   (c) $-2av^3$
   (d) $2av^2$

8. A car, starting from rest, accelerates at the rate t through a distance S, then continues at constant speed for time t and then accelerates at the rate f/2 to come to rest. If the total distance travelled is 15 S, then
    (a) S = ft
    (b) S = 1/6 ft^2
    (c) S = 1/2 ft^2
    (d) S = 1/4 ft^2

9. A particle is moving, eastwards with a velocity of 5 ms^{-1}. In 10 s, the velocity changes to 5 ms^{-1} northwards. The average acceleration in this time is
    (a) $1/\sqrt{2}$ ms^{-2} towards north-east
    (b) ½ ms^{-2} towards north
    (c) zero
    (d) $1/\sqrt{2}$ ms^{-2} towards north-west

10. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m/s^2. He reaches the ground with a speed of 3 m/s. At what height, did he bail out?
    (a) 91 m
    (b) 182 m
    (c) 293 m
    (d) 111 m

11. A block is kept on a frictionless inclined surface with angle of inclination a. the incline is given an acceleration a to keep the block stationary. Then, a is equal to
    (a) g/tan a
    (b) g cosec a
    (c) g
    (d) g tan a

12. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. it rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is
    (a) 40 m/s
    (b) 20 m/s
    (c) 10 m/s
    (d) $10\sqrt{30}$ m/s

13. A body A of mass M while falling vertically downwards under gravity breaks into two parts; a body B of mass 1/3 M and a body C of mass 2/3 M. The centre of mass of bodies B and C taken together shifts compared to that of body A towards
    (a) depends on height of breaking
    (b) does not shift
    (c) body C
    (d) body B

14. The moment of inertia of uniform semi-circular disc of mass M and radius r about a line perpendicular to the plane of the disc through the centre is
    (a) 1/4 Mr^2
    (b) 2/5 Mr^2
    (c) Mr^2
    (d) 1/2 Mr^2

15. A particle of mass 0.3 kg is subjected to a force F = - kx with k = 15 N / m. What will be its initial acceleration, if it is released from a point 20 cm away from the origin?
    (a) 3 m/s^2
    (b) 15 m/s^2
    (c) 5 m/s^2
    (d) 10 m/s^2

16. The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant k and compresses it by length L. The maximum momentum of the block after collision is
(a) $\sqrt{Mk}$ L
(b) $kL^2/2M$
(c) zero
(d) ML^2/k

17. A mass m moves with a velocity v and collides inelastically with another identical mass. After collision the 1st mass moves with velocity $v/\sqrt{3}$ in a direction perpendicular to the initial direction of motion. Find the speed of the second mass after collision.
(a) v
(b) $\sqrt{3}$ v
(c) $2/\sqrt{3}$ v
(d) $v/\sqrt{3}$

18. A 20 cm long capillary tube is dipped in water. The water rises upto 8 cm. If the entire arrangement is put in a freely falling elevator, the length of water column in the capillary tube will be
(a) 8 cm
(b) 10 cm
(c) 4 cm
(d) 20 cm

19. If S is stress and Y is Young's modulus of material of a wire, the energy stored in the wire per unit volume is
(a) $2S^2Y$
(b) $S^2/2Y$
(c) $2Y/S^2$
(d) $S/2Y$

20. Average density of the earth
(a) does not depend on g
(b) is a complex function of g
(c) is directly proportional to g
(d) is inversely proportional to g

21. A body of mass m is accelerated uniformly from rest to a speed v in a time T. The instantaneous power delivered to the body as a function of time, is given by
(a) $mv^2/T^2 \, t$
(b) $mv^2/T^2 \, t^2$
(c) $1/2 \, mv^2/T^2 \, t$
(d) ½ $mv^2/T^2 \, t^2$

22. Consider a car moving on a straight road with a speed of 100 m/s. The distance at which car can be stopped, is [$\mu_k = 0.5$]
(a) 800 m
(b) 1000 m
(c) 100 m
(d) 400 m

23. Which of the following is incorrect regarding the first law of thermodynamics?
(a) It is not applicable to any cyclic process
(b) It is a restatement of the principle of conservation of energy
(c) It introduces the concept of the internal energy
(d) It introduces the concept of the entropy

24. A T shaped object with dimensions shown in the figure, is lying on a smooth floor. A force F is applied at the point P parallel to AB, such that the object has only the translational motion without rotation. Find the location of P with respect to C.
(a) 2/3 l
(b) 3/2 l
(c) 4/3 l
(d) l

25. The change in the value of g at a height h above the surface of the earth is the same as at a depth d below the surface of earth. When both d and h are much smaller than the radius of earth, then which one of the following is correct?
(a) d = h/2
(b) d = 3h/2
(c) d = 2h
(d) d = h

26. A particle of mass 10 g is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. find the work to be done against the gravitational force between them, to take the particle far away from the sphere. (You may take G = 6.67 x 10^{-11} Nm^2 / kg^2)
(a) 13.34 x 10^{-10} J
(b) 3.33 x 10^{-10} J
(c) 6.67 x 10^{-9} J
(d) 6.67 x 10^{-10} J

27. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio C_p/C_v of the mixture is
(a) 1.59
(b) 1.62
(c) 1.4
(d) 1.54

28. The intensity of gamma radiation from a given source is I. On passing through 36 mm of lead, if it reduced to I/8. The thickness of lead, which will reduce the intensity to 1/2 will be
(a) 6 mm
(b) 9 mm
(c) 18 mm
(d) 12 mm

29. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm, is incident on it. The bandgap for the semiconductor is
(a) 1.1 eV
(b) 2.5 eV
(c) 0.5 eV
(d) 0.7 eV

30. A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is placed 0.5 m away, the number of electrons emitted by photocathode would
(a) decrease by a factor of 4
(b) increase by a factor of 4
(c) decrease by a factor of 2
(d) increase by a factor of 2

CHEMISTRY

31. The oxidation state of Cr in $[Cr(NH_3)_4 Cl_2]^+$ is
    (a) 0   (b) +1
    (c) +2   (d) +3

32. Which one of the following types of drugs reduces fever?
    (a) Tranquiliser   (b) Antibiotic
    (c) Antipyretic   (d) Analgesic

33. Which of the following oxides is amphoteric in character?
    (a) SnO_2 (b) SiO_2
    (c) CO_2 (d) CaO

34. Which one of the following oxides is amphoteric in character?
    (a) H_2^- (b) H_2^+
    (c) H_2 (d) He_2^+

35. If a is the degree of dissociation of Na_2SO_4, the van't Hoff factor (i) used for calculating the molecular mass is
    (a) 1-2a   (b) 1+2a
    (c) 1-a   (d) 1+a

36. Which of the following is a polyamide?
    (a) Bakelite   (b) Terylene
    (c) Nylon-66   (d) Teflon

37. Due to the presence of an unpaired electron, free radicals are
    (a) cations   (b) anions
    (c) chemically inactive   (d) chemically reactive

38. For a spontaneous reaction the ΔG, equilibrium constant (K) and E^0_{cell} will be respectively
    (a) –ve, > 1, -ve   (b) –ve, < 1, -ve
    (c) +ve, > 1, -ve   (d) –ve, > 1, +ve

39. Hydrogen bomb is based on the principle of
    (a) artificial radioactivity   (b) nuclear fusion
    (c) natural radioactivity   (d) nuclear fission

40. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ions on the centres of the faces of the cube. The empirical formula for this compound would be
    (a) A_3B (b) AB_3
    (c) A_2B (d) AB

41. The highest electrical conductivity of the following aqueous solutions is of
    (a) 0.1 M difluoroacetic acid   (b) 0.1 M fluoroacetic acid
    (c) 0.1 M chloroacetic acid   (d) 0.1 M acetic acid

42. Lattice energy of an ionic compound depends upon
    (a) charge on the ion and size of the ion
    (b) packing of ions only
    (c) size of the ion only
    (d) charge on the ion only

43. Consider an endothermic reaction X → Y with the activation energies E_b and E_t for the backward and forward reactions respectively. In general
    (a) there is no definite relation between E_b and E_t
    (b) $E_b = E_t$
    (c) $E_b > E_t$
    (d) $E_b < E_t$

44. Aluminium oxide may be electrolysed at 1000ºC to furnish aluminium metal (Atomic mass = 27 u; 1 Faraday = 96500.
    The cathode reaction is
       $Al^{3+} + 3e^- \rightarrow Al^0$
    To prepare 5.12 kg of aluminium metal by this method would require
    (a) 5.49×10^1 C of electricity   (b) 5.49×10^4 C of electricity
    (c) 1.83×10^7 C of electricity   (d) 5.49×10^7 C of electricity

45. The volume of a colloidal particle, V_c as compared to the volume of a solute particle in a true solution V_s, could be
    (a) $V_c/V_s = 10^3$ (b) $V_c/V_s = 10^{-3}$
    (c) $V_c/V_s = 10^{23}$ (d) $V_c/V_s = 1$

46. Consider the reaction $N_2 + 3H_2 \rightarrow 2NH_3$ carried out at constant temperature and pressure. If ΔH and ΔU are the enthalpy and internal energy changes for the reaction, which of the following expressions is true?
    (a) ΔH > ΔU   (b) ΔH < ΔU
    (c) ΔH = ΔU   (d) ΔH = 0

47. The solubility product of a salt having general formula MX_2, in water is 4×10^{-12}. The concentration of M^{2+} ions in the aqueous solution of the salt is
    (a) 4.0×10^{-1} M   (b) 1.6×10^{-4} M
    (c) 1.0×10^{-4} M   (d) 2.0×10^{-6} M

48. Benzene and toluene from nearly ideal solutions. At 20ºC, the vapour pressure of benzene is 75 torr and that of toluene is 22 torr. The partial vapour pressure of benzene at 20ºC for a solution containing 78 g of benzene and 46 g of toluene in torr is
    (a) 53.5   (b) 37.5
    (c) 25   (d) 50

49. Which one of the following statements is not true about the effect of an increase in temperature on the distribution of molecular speeds in a gas?
    (a) The area under the distribution curve remains the same as under the lower temperature
    (b) The distribution becomes broader
    (c) The fraction of the molecules with the most probable speed increases
    (d) The most probable speed increases

50. For the reaction,
    $2NO_2(g)$ 2 $NO(g) + O_2(g)$ ($K_c = 1.8 \times 10^{-6}$ at 184ºC)
        (R = 0.00831 kJ/(molK))
    When K_p and K_c are compared at 184ºC it is found that
    (a) whether K_p is greater than, less than or equal to K_c depends upon the total gas pressure
    (b) $K_p = K_c$
    (c) K_p is less than K_c
    (d) K_p is greater than K_c

51. The exothermic formation of CIF_3 is represented by the equation
    $Cl_2(g) + 3F_2(g)$ $2CIF_3(g)$; $\Delta H_r = -329$ kJ
    Which of the following will increase the quantity of CIF_3 in an equilibrium mixture of Cl_2, F_2 and CIF_3 ?
    (a) Adding F_2
    (b) Increasing the volume of the container
    (c) Removing Cl_2
    (d) Increasing the temperature

52. Hydrogen ion concentration in mol/L in a solution of pH = 5.4 will be
    (a) 3.98×10^{-6} (b) 3.68×10^{-6}
    (c) 3.88×10^{6} (d) 3.9×10^{8}

53. A reaction involving two different reactants can never be
    (a) bimolecular reaction   (b) second order reaction
    (c) first order reaction   (d) unimolecular reaction

54. Two solutions of a substance (non electrolyte) are mixed in the following manner.
    480 mL of 1.5 M first solution +520 mL of 1.2 M second solution.
    What is the molarity of the final mixture?
    (a) 2.70 M   (b) 1.344 M
    (c) 1.50 M   (d) 1.20 M

55. During the process of electrolytic refining of copper, some metals present as impurity settle as 'anode mud'. These are
    (a) Fe and Ni   (b) Ag and Au
    (c) Pb and Zn   (d) Se and Ag

56. Calculate Λ^∞HOAc using appropriate molar conductances of the electrolytes listed above at infinite dilution in H_2O at 25ºC

Electrolyte	KCl	KNO$_3$	HCl	NaOAc	NaCl
Λ^∞ (S cm^2 mol^{-1})	149.9	145.0	426.2	91.0	126.5

(a) 217.5   (b) 390.7
(c) 552.7   (d) 517.2

57. If we consider that 1/6, in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will
    (a) be a function of the molecular mass of the substance
    (b) remain unchanged
    (c) increase two fold
    (d) decrease twice

58. In a multi-electron atom, which of the following orbitals described by the three quantum numbers will have the same energy in the absence of magnetic and electric fields?
    (A) n = 1, / = 0, m = 0   (B) n = 2, / = 0, m = 0
    (C) n = 2, / = 1, m = 1   (D) n = 3, / = 2, m = 1
    (E) n = 3, / = 2, m = 0
    (a) (D) and (E)   (b) (C) and (D)
    (c) (B) and (C)   (d) (A) and (B)

59. Based on lattice energy and other considerations which one of the following alkali metal chlorides is expected to have the highest melting point?
    (a) RbCl   (b) KCl
    (c) NaCl   (d) LiCl

60. A schematic plot of In K_{eq} versus inverse of temperature for a reaction is shown below
    Log K_{eq} = -$\Delta H°$/2.303 RT + -$\Delta S°$/R
    The reaction ust be
(a) highly spontaneous at ordinary temperature
(b) one with negligible enthalpy change
(c) endothermic
(d) exothermic

MATHEMATICS

61. If C is the mid-point of AB and P is any point outside AB, then
    (a) PA + PB + PC = 0
    (b) PA + PB + 2PC = 0
    (c) PA + PB = PC
    (d) PA + PB = 2PC

62. Let P be the point (1,0) and Q be a point on the locus $y^2 = 8x$. The locus of mid-point of PQ is
    (a) $x^2 - 4y + 2 = 0$
    (b) $x^2 + 4y + 2 = 0$
    (c) $y^2 + 4x + 2 = 0$
    (d) $y^2 - 4x + 2 = 0$

63. If in a frequency distribution, the mean and median are 21 and 22 respectively, then its mode is approximately
    (a) 24.0
    (b) 25.5
    (c) 20.5
    (d) 22.0

64. Let R – {(3,3), (6,6), (9,9), (12,12), (6,12), (3,9), (3,12), (3,6)} be a relation on the set A = {3,6,9,12}. The relation is
    (a) reflexive and symmetric only
    (b) an equivalence relation
    (c) reflexive only
    (d) reflexive and transitive only

65. If $A^2 - A + I = O$, then the inverse of A is
    (a) I – A
    (b) A – I
    (c) A
    (d) A + I

66. If the cube roots of unity are $1, \omega, \omega^2$, then the roots of the equation $(x-1)^3 + 8 = 0$, are
    (a) -1, $1+2\omega$, $1+2\omega^2$
    (b) -1, $1-2\omega$, $1-2\omega^2$
    (c) -1, -1, -1
    (d) -1, $-1+2\omega$, $-1-2\omega^2$

67. $[1/n^2 \sec^2 1/n^2 + 2/n^2 \sec^2 4/n^2 + \ldots + n/n^2 \sec^2 1]$ equals
    (a) 1/2 tan 1
    (b) tan 1
    (c) 1/2 cosec 1
    (d) ½ sec 1

68. Area of the greatest rectangle that can be inscribed in the ellipse $x^2/a^2 + y^2/b^2 = 1$ is
    (a) a/b
    (b) $\sqrt{ab}$
    (c) ab
    (d) 2 ab

69. The differential equation representing the family of curves $y^2 = 2c(x + \sqrt{c})$, where c > 0, is a parameter, is of order and degree as follows
    (a) order 2, degree 2
    (b) order 1, order 3
    (c) order 1, degree 1
    (d) order 1, degree 2

70. ABC is triangle, Forces P,Q,R acting along IA, IB and IC respectively are in equilibrium, where I is the incentre of ΔABC. Then, P : Q : R is
    (a) cos A : cos B : cos C
    (b) cos A/2 : cos B/2 : cos C/2
    (c) sin A/2 : sin B/2 : sin C/2
    (d) sin A : sin B : sin C

71. If the coefficients of rth, (r+1)th and (r+2)th terms in the binomial expansion of $(1+y)^m$ are in AP, then m and r satisfy the equation
(a) $m^2 - m(4r-1) + 4r^2 + 2 = 0$
(b) $m^2 - m(4r+1) + 4r^2 - 2 = 0$
(c) $m^2 - m(4r+1) + 4r^2 + 2 = 0$
(d) $m^2 - m(4r-1) + 4r^2 - 2 = 0$

72. In a ΔPQR, R = $\pi/2$. If tan (P/2) and tan (Q/2) are the roots of $ax^2 + bx + c = 0$, a ≠ 0, then
(a) b = a + c
(b) b = c
(c) c = a + b
(d) a = b + c

73. If the letters of the word SACHIN are arranged in all possible ways and these words are written out as in dictionary, then the word SACHIN appears at serial number
(a) 602
(b) 603
(c) 600
(d) 601

74. The value of $^{50}C_4 + {}^{56-r}C_3$ is
(a) $^{56}C_4$
(b) $^{56}C_3$
(c) $^{55}C_3$
(d) $^{55}C_4$

75. If A = , then which one of the following holds for all n 1, by the principle of mathematical induction?
(a) $A^n = 2^{n-1} A + (n-1)I$
(b) $A^n = nA + (n-1)I$
(c) $A^n = 2^{n-1} A - (n-1)I$
(d) $A^n = nA-(n-1)I$

76. If the coefficient of x^7 in $[ax^2 + (1/bx)]^{11}$ equals the coefficient of x^{-7} in $[ax-(1/bx^2)]^{11}$, then a and b satisfy the relation
(a) ab = 1
(b) a/b = 1
(c) a + b = 1
(d) a − b = 1

77. Let f: (-1,1) → B be a function defined by f(x) = $\tan^{-1}$ 2x/1-x^2, then f is both one-one and onto when B is the interval
(a) (-$\pi/2$, $\pi/2$)
(b) [-$\pi/2$, $\pi/2$]
(c) [0, $\pi/2$]
(d) (0, $\pi/2$)

78. If z_1 and z_2 are two non-zero complex numbers such that $|z_1 + z_2|=|z_1|+|z_2|$, then arg (z_1)- arg (z_2) is equal to
(a) - $\pi/2$
(b) 0
(c) –π
(d) $\pi/2$

79. If $w = \dfrac{z}{z-1/3i}$ and |w| = 1, then z lies on
(a) a parabola
(b) a straight line
(c) a circle
(d) an ellipse

80. If $a^2 + b^2 + c^2 = -2$ and

$$F(x) = \begin{vmatrix} 1+a^2x & (1+b^2)x & (1+c^2)x \\ (1+a^2)x & 1+b^2x & (1+c^2)x \\ (1+a^2)x & (1+b^2)x & 1+c^2x \end{vmatrix},$$

then f(x) is a polynomial of degree

(a) 2   (b) 3

(c) 0   (d) 1

81. The system of equations
$\alpha x + y + z = \alpha - 1$, $x + \alpha y + z = \alpha - 1$ $x + y + \alpha z = \alpha - 1$ has no solution, if a is

(a) 1   (b) not -2

(c) either -2 or 1   (d) -2

82. The value of a for which the sum of the squares of the roots of the equation $x^2 - (a-2)x - a - 1 = 0$ assume the least value is

(a) 2   (b) 3

(c) 0   (d) 1

83. If the roots of the equation $x^2 - bx + c = 0$ are two consecutive integers, then $b^2 - 4c$ equals

(a) 1   (b) 2

(c) 3   (d) -2

84. Suppose f(x) is differentiable at x = 1 and 1/h f(1+h) = 5, then f'(1) equals

(a) 6   (b) 5

(c) 4   (d) 3

85. Let f be differentiable for all x. If f(1) = - 2 and f'(x)2 for x∈|1,6|, then

(a) f(6) = 5   (b) f(6) < 5

(c) f(6) < 8   (d) f(6) 8

86. If f is a real-valued differentiable function satisfying $|f(x)-f(y)|(x-y)^2$, $x, y \in R$ and f(0)=0, then f(1) equals

(a) 1   (b) 2

(c) 0   (d) -1

87. If x is so small that x^3 and higher powers of x may be neglected, then $(1+x)^{3/2} - (a + \frac{1}{2}x)^3 / (1-x)^{1/2}$ may be approximated as

(a) $\frac{x}{x} - \frac{3}{8}x^2$ (b) $-\frac{3}{8}x^2$

(c) $3x + \frac{3}{8}x^2$ (d) $1 - \frac{3}{8}x^2$

88. If $x = a^n$, $y = b^n$, $z = c^n$, where a, b, c are in AP and $|a|<1, |b|<1, |c|<1$, then x, y, z are in

(a) HP   (b) AGP

(c) AP   (d) GP

89. In a ΔABC, let $C = \pi/2$, if r is the inradius and R is the circumradius of the ΔABC, then $2(r + R)$ equals

(a) c + a

(b) a + b + c

(c) a + b

(d) b + c

90. If $\cos^{-1} x - \cos^{-1} \frac{y}{2} = a$, then $4x^2 - 4xy \cos a + y^2$ is equal to

(a) $-4 \sin^2 a$

(b) $4 \sin^2 a$

(c) 4

(d) $2 \sin 2a$