W-1

Entrance Examination - 2020
M.Sc. (5 - Year Integrated) Sciences
(Chemistry, Mathematics, Physics, Systems Biology and Applied Geology)

Time : 2 hours   Max. Marks: 100

Hall Ticket Number :

Instructions

Please read the following instructions carefully

1. (a) Write your Hall ticket Number in the above box AND on the OMR sheet without fail.
    (b) Fill in the OMR sheet, the Booklet Code given above at the top left corner of this sheet. Candidates should also read and follow the other instructions given in the OMR sheet.

2. All answers should be marked clearly on the OMR answer sheet only.

3. There are 100 questions in this paper. Questions 1- 25 are in Biology, 26-50 are in Chemistry, 51-75 are in Mathematics and 76 - 100 are in Physics.

4. **There is negative marking. Each correct answer carries 1 (one) mark and for every wrong answer -0.33 mark will be deducted. Each question has only one correct option.**

5. The appropriate answer should be coloured with either a blue or a black ball point pen. DO NOT USE A PENCIL.

6. Hand over the **OMR answer sheet** at the end of the examination to the invigilator.

7. Use of non programmable calculators and log-tables is allowed.

8. Use of mobile phone is NOT allowed inside the hall.

9. No additional sheets will be provided. Rough work can be done in the question paper itself/space provided at the end of the booklet.

10. This question booklet contains __2 6__ pages including this page and the pages for the rough work. Please check that your paper has all the pages before answering.

11. All the symbols used in the text have their usual meanings.

BIOLOGY

1. Which one is **CORRECT** about cell division in a human cell?

   [A] The chromosome number in daughter cells remains same for every cell type.
   [B] The chromosome number in daughter cells becomes half for every cell type.
   [C] Not all cells retain the ability to divide.
   [D] All cells keep dividing at periodic intervals.

2. In a human body, which body part or product has **LEAST** number of microbes?

   [A] urine
   [B] stool
   [C] gut
   [D] oral cavity

3. Choose the option that correctly matches contents in Column A with contents in Column B.

Column A	Column B
(i) Endosperm	(a) tissue having reserve food materials
(ii) Embryo	(b) tissue that will develop into shoot
(iii) Pollen	(c) mass of cells which develops from a fertilized egg
(iv) Plumule	(d) male gametophyte

   [A] i – c, ii – a, iii – b, iv - d
   [B] i – b, ii – a, iii – d, iv - c
   [C] i – d, ii – c, iii – b, iv - a
   [D] i – a, ii – c, iii – d, iv – b

4. During photosynthesis, the metabolic reactions involving fixation of carbon dioxide into sugar, through use of NADPH and ATP, can happen

   [A] either in light or dark
   [B] only in presence of light
   [C] only in dark
   [D] only when the light intensity is above a threshold value, and of a particular wavelength

5. In the recent epidemic of coronavirus, the majority of the infected individuals recover typically in 2-3 weeks. The recovery can be attributed mainly to:

   [A] phagocytosis of the viral population by macrophages
   [B] action of B- and T-Lymphocytes, such as, production of virus specific antibodies
   [C] virus lifecycle is of 2-3 weeks, after which virus leaves the host
   [D] inflammatory response involving action of mast cells

6. DNA has a helical structure comprised of two strands. If the nucleotide sequence of one of the strands is 5'-AAGGTTCC-3', sequence of another strand will be:

   [A] 5'-GGAACCTT-3'
   [B] 5'-GGAACCUU-3'
   [C] 5'-TTCCAAGG-3'
   [D] 5'-UUCCAAGG-3'

BIOLOGY

7. Which one of the following enzyme is responsible for the conversion of caseinogen to solid casein which turns the milk to curd ?

    [A] Trypsin
    [B] Renin
    [C] Pepsin
    [D] Rennin

8. The process of transfer of genetic material from bacteriophage to bacteria is known as

    [A] Conjugation
    [B] Transformation
    [C] Transduction
    [D] Conduction

9. The enzyme lipase that catalyzes the hydrolysis of fats is secreted in

    [A] Stomach
    [B] Gallbladder
    [C] Pancreas
    [D] Small Intestine

10. The smallest and largest bones in the human body are, respectively

    [A] Incus and Humor
    [B] Stapes and Femur
    [C] Stapes and Humor
    [D] Incus and Femur

11. Which of the following vitamins can be primarily obtained from animal food?

    [A] VitaminB2
    [B] VitaminB6
    [C] VitaminB9
    [D] Vitamin B12

12. Which of the following cells are *NOT* found in xylem?

    [A] Fibers
    [B] Sieve tubes
    [C] Vessels
    [D] Parenchyma

BIOLOGY

13. Choose the option that correctly matches the biomolecules in Column A with the category it belongs in Column B.

Column A
(i) Collagen
(ii) Carotenoid
(iii) Cellulose
(iv) Chain of Cytidine monophosphate

Column B
(a) Secondary metabolite
(b) Nucleic acid
(c) Protein
(d) Carbohydrate

[A] i – d, ii – c, iii – a, iv – b
[B] i – c, ii – a, iii – d, iv – b
[C] i – b, ii – b, iii – d, iv – a
[D] i – d, ii – c, iii – b, iv – a

14. In an enzyme catalyzed biochemical reaction, with increase in substrate concentration, the rate of reaction will:

[A] increase till it reaches it maximum velocity
[B] decrease exponentially and then linearly till it stops
[C] not change
[D] increase at a constant value

15. Choose the option that correctly matches the taxonomic group in Column A with the features in Column B.

Column A
(i) Echinodermata
(ii) Mammals
(iii) Arthropoda
(iv) Platyhelminthes

Column B
(a) aceolomates
(b) joint appendages
(c) viviparous
(d) water vascular system

[A] i – c, ii – a, iii – d, iv – c
[B] i – b, ii – c, iii – d, iv – a
[C] i – d, ii – c, iii – b, iv – a
[D] i – d, ii – a, iii – c, iv – b

16. The two (right and left) ventricles of a four-chambered human heart will pump blood primarily to:

[A] kidney and liver
[B] brain and kidney
[C] brain and digestive system
[D] lungs and body parts

17. A reflex action involves signal transmission through multiple components of neural system. Arrange components in order, starting from sensing stimulus to the involuntary response:
(i) motor neuron (ii) dorsal root ganglion (iii) afferent (receptor) neuron (iv) efferent neuron (effector) (v) spinal cord

[A] iii, ii, v, i, iv
[B] iii, v, iv, ii, i
[C] i, iii, ii, v, iv
[D] iii, v, ii, iv, i

BIOLOGY

18. In a dihybrid cross between a double heterozygous female & a double homozygous recessive male, the frequency of recombinants (among offsprings) for a pair of *completely linked* traits will be:

[A] 50%
[B] approximately 33%
[C] approximately 25%
[D] 0%

19. Darwin observed variety of finches on Galapagos island, located off west coast of South America, which led him to propose:

[A] these finches acquired the traits from other birds of the island by inter-species crossing
[B] such finches already existed on mainland, and several of them migrated to those islands
[C] finches are the only species showing highest natural diversity among animals
[D] the adaptations in the beaks which provided better fitness were naturally selected

20. Choose the option that matches the type of interaction in Column A with the description in Column B.

Column A	Column B
(i) Mutualism	(a) one species is benefited while the other is unaffected
(ii) Commensalism	(b) one species is harmed whereas the other is unaffected.
(iii) Amensalism	(c) both the species benefit
(iv) Predation	(d) one species benefits at the cost of another

[A] i - c, ii - a, iii - b, iv - d
[B] i - d, ii - a, iii - b, iv - c
[C] i - b, ii - c, iii - a, iv – d
[D] i - c, ii - d, iii - a, iv – b

21. The correct contribution of nephrological processes during formation of urine in human kidneys is given by:

[A] glomerular filtration + tubular reabsorption + tubular secretion
[B] glomerular filtration - tubular reabsorption - tubular secretion
[C] glomerular filtration + tubular reabsorption - tubular secretion
[D] glomerular filtration - tubular reabsorption + tubular secretion

22. Match these cells with respective organs

(i) Kupffer Cells	(a) Pancreas
(ii) Purkinje Cells	(b) Bone
(iii) Osteoclasts	(c) Liver
(iv) Acinar Cells	(d) Brain

[A] i - c, ii - a, iii - b, iv - d
[B] i - d, ii - a, iii - b, iv - c
[C] i - b, ii - c, iii - a, iv - d
[D] i - c, ii - d, iii - b, iv – a

BIOLOGY

23. Which one is *ODD* based on etiology of the disease?

    [A] Hepatitis B
    [B] Typhoid
    [C] Plague
    [D] Dysentery

24. Which form of symmetry marks the beginning of body plans of animals?

    [A] Spherical symmetry
    [B] Radial symmetry
    [C] Bilateral symmetry
    [D] Asymmetry

25. Phototropism is the response of plants to light. This happens because of the action of which plant hormone?

    [A] Gibberellins
    [B] Cytokinins
    [C] Auxin
    [D] Abscisic acid

CHEMISTRY

26. If NaCl is doped with 10^{-4} mol % of $SrCl_2$, the concentration of cation vacancies will be (N_A = 6.02 x 10^{23} mol^{-1})

    [A] 6.02 x 10^{16} mol^{-1}
    [B] 6.02 x 10^{17} mol^{-1}
    [C] 6.02 x 10^{14} mol^{-1}
    [D] 6.02 x 10^{15} mol^{-1}

27. The correct order of bond order values among the following

    (a) NO^- (b) NO^+ (c) NO (d) NO^{2+} (e) NO^{2-}

    [A] a<d<c<b<e
    [B] d=b<a<e<c
    [C] e<a<d=c<b
    [D] b<c<d<a<e

28. The element with atomic number 117 is placed in which of the following family

    [A] Alkali Metals
    [B] Alkaline Earth Metals
    [C] Coinage Metals
    [D] Halogens

29. A common test for identifying a nitrate ion is a "brown ring" test. Composition of the complex formed is:

    [A] $[Fe(H_2O)_3(NO_2)_3]$
    [B] $[Fe(H_2O)_6](NO)_2$
    [C] $[Fe(H_2O)_4(SO_4)_2](NO_2)$
    [D] $[Fe(H_2O)_5(NO)]SO_4$

30. The unit cell with crystallographic dimensions $a=b \neq c$, $\alpha=\beta=\gamma=90°$ is

    [A] Orthorhombic
    [B] Tetragonal
    [C] Hexagonal
    [D] Cubic

31. Which of the following molecules can act as an oxidizing as well as reducing agent?

    [A] H_2S
    [B] SO_3
    [C] H_2O_2
    [D] F_2

CHEMISTRY

32. A 0.0020 M aqueous solution of an ionic compound $Co(NH_3)_5(NO_2)Cl$ freezes at
   − 0.00732 °C. Number of moles of ions which 1 mol of ionic compound produces on being
   dissolved in water will be (k_f = -1.86 °C/m)

   [A] 1
   [B] 2
   [C] 3
   [D] 4

33. In an atom an electron is moving with a speed of 600 m/s with an accuracy of 0.005%.
   Certainty with which the position of the electron can be located is (h = 6.6×10^{-34} kg m^2 s^{-1},
   mass of electron, e_m = 9.1×10^{-31} kg)

   [A] 1.52×10^{-4} m
   [B] 5.10×10^{-3} m
   [C] 1.92×10^{-3} m
   [D] 3.84×10^{-3} m

34. Pure benzene freezes at 5.3 °C. A solution of 0.223 g of phenyl acetic acid ($C_6H_5CH_2COOH$)
   in 4.4 g of benzene (K_f = 5.12 K kg mol^{-1}) freezes at 4.47 °C. From the observation one can
   conclude that:

   [A] phenyl acetic acid dimerizes in benzene
   [B] phenyl acetic acid undergoes complete ionization in benzene
   [C] phenyl acetic acid exists as such in benzene
   [D] phenyl acetic acid undergoes partial ionization in benzene

35. The radius of first Bohr orbit of hydrogen atom is 0.529 Å. Calculate the radius of the third
   orbit of He$^+$ ion

   [A] 1.59 Å
   [B] 1.41 Å
   [C] 0.705 Å
   [D] 2.38 Å

36. As $O_{2(l)}$ is cooled at 1 atm, it freezes at 54.5 K to form Solid I. At a lower temperature, Solid
   I rearrange to Solid II, which has a different crystal structure. Thermal measurements show
   that for the phase transition of Solid I to II, ΔH = -743.1 J/mol, and ΔS = 17.0 J/K^{-1} mol^{-1}. At
   what temperature are solids I and II in equilibrium?

   [A] 53.4 K
   [B] 2.06 K
   [C] 31.5 K
   [D] 43.7 K

W-1

CHEMISTRY

37. The emf of Daniell cell at 298 K is E_1.

    $Zn|ZnSO_4(0.01\ M)||CuSO_4(1.0\ M)|Cu$

    When the concentration of $ZnSO_4$ is 1.0 M and that of $CuSO_4$ is 0.01 M, the emf changed to E_2. What is the relation between E_1 and E_2 ?

    [A] $E_1 = E_2$
    [B] $E_1 < E_2$
    [C] $E_1 > E_2$
    [D] $E = 0 \neq E_2$

38. The de-Broglie wavelength of an electron is 66 nm. The velocity of the electron is
    ($h = 6.6 \times 10^{-34}$ kg m^2 s^{-1}, m$= 9.0 \times 10^{-31}$kg)

    [A] 1.84×10^{-4} ms^{-1}
    [B] 1.1×10^6 ms^{-1}
    [C] 5.4×10^3 ms^{-1}
    [D] 1.1×10^4 ms^{-1}

39. By what factor does the rms speed of any ideal gas change when the temperature is increased from 100 °C to 200 °C?

    [A] 1.0
    [B] 2.0
    [C] 1.13
    [D] 4.0

40. If all the lattice points of an FCC structure are occupied by uniform hard spheres that touch each other, the fraction of volume occupied is

    [A] $\dfrac{\pi\sqrt{3}}{8}$

    [B] $\dfrac{\pi\sqrt{3}}{7}$

    [C] $\dfrac{\pi\sqrt{2}}{6}$

    [D] $\dfrac{\pi}{6}$

41. 1 mg of Na^{24} was injected into the blood of a patient. How long will it take for the radio activity to fall to 10% of the initial value? Half-life of Na^{24} is 14.8 Hours.
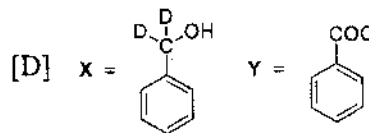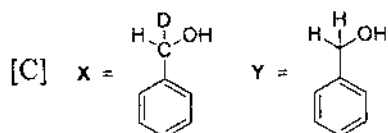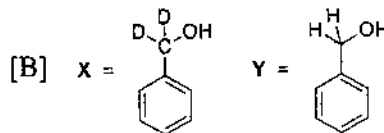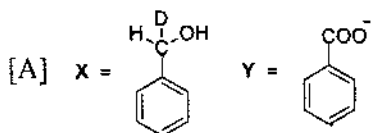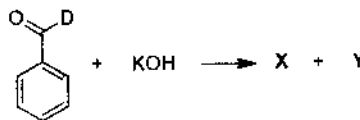
    [A] 23.49 Hours
    [B] 68.23 Hours
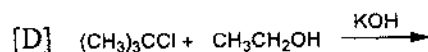   [C] 73.75 Hours
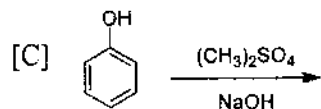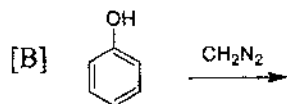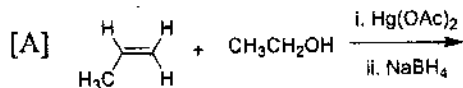   [D] 49.19 Hours

CHEMISTRY

42. Which one of the following electrophilic substitution reaction on benzene is reversible

    [A] Nitration
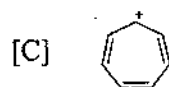   [B] Sulfonation
    [C] Halogination
    [D] Acylation

43. The products **X** and **Y** in the following reaction are

    [A]   X =   Y =
    [B]   X =   Y =

    [C]   X =   Y =
    [D]   X =   Y =

44. Which of the following reaction does not involve the formation of ether.

    [A]   [alkene] + CH_3CH_2OH $\xrightarrow[\text{ii. NaBH}_4]{\text{i. Hg(OAc)}_2}$

    [B]   [phenol] $\xrightarrow{CH_2N_2}$

    [C]   [phenol] $\xrightarrow[\text{NaOH}]{(CH_3)_2SO_4}$

    [D] $(CH_3)_3CCl$ + CH_3CH_2OH $\xrightarrow{KOH}$

45. Which of the following is antiaromatic according to Huckel rule?

    [A]   [B]

    [C]   [D]

CHEMISTRY

46. Find the product **X** in the following $CH_3COOH \xrightarrow[\text{iii. } H_3O^+]{\begin{array}{c}\text{i. } Br_2, P \\ \text{ii. KCN}\end{array}}$ **X** reaction

 [A] Succinic acid
 [B] Malonic acid
 [C] Glyconic acid
 [D] α-hydroxy propionic acid
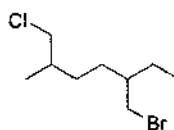
47. The correct order of acidic nature of the given compounds is

 [A] III > IV > II > I
 [B] IV > III > I > II
 [C] III > II > I > IV
 [D] II > III > IV > I

48. The IUPAC name of the following compound is

 [A] 5-(bromomethyl)-1-chloro-2-methylheptane
 [B] 2-ethyl-5-methyl-1-bromo-6-chlorohexane
 [C] 3-(chloromethyl)-6-(bromomethyl)heptane
 [D] 1-bromo-6-chloro-2-methyl-5-ethylhexane

49. The artificial sweetener "Aspartame" is methyl ester of the following dipeptide

 [A] Lysine and Phenyl alanine
 [B] Phenyl alanine and Aspartic acid
 [C] Aspartic acid and Lysine
 [D] Glutamine and Aspartic acid

50. When $CH_2=CH-CH_2-COOH$ is reduced with $LiAlH_4$, the compound obtained will be

 [A] $CH_2=CH-CH_2-CH_2OH$
 [B] $CH_3-CH_2-CH_2-CH_2OH$
 [C] $CH_3-CH_2-CH_2-CHO$
 [D] $CH_3-CH_2-CH_2-COOH$

$\omega-1$

MATHEMATICS

51. Let two sets A and B have m and n elements, respectively. If the total number of subsets of A is 56 more than the total number of subsets of B, then (m, n) is

 [A] (7,6)
 [B] (6,3)
 [C] (5,1)
 [D] (8,7)

52. Let R be the relation defined on the set of all real numbers such that $R = \{(x, y) : \operatorname{cosec}^2 x - \cot^2 y = 1\}$. Then R is

 [A] reflexive and symmetric but not transitive
 [B] reflexive and transitive but not symmetric
 [C] symmetric and transitive but not reflexive
 [D] an equivalence relation

53. Let the quadratic equation $p(x) = 0$ with the real coefficients have purely imaginary roots. Then the equation $p(p(x)) = 0$ has

 [A] only purely imaginary roots
 [B] all real roots
 [C] two real and two purely imaginary roots
 [D] neither real nor purely imaginary roots

54. The system of equations $\alpha x + y + z = \alpha - 1, x + \alpha y + z = \alpha - 1$ and $x + y + \alpha z = \alpha - 1$ has no solution, for α equals to

 [A] -1
 [B] -2
 [C] 2
 [D] 1

55. If $f : \mathbb{R} \to \mathbb{R}$ satisfies $f(x + y) = f(x) + f(y)$, for all $x, y \in \mathbb{R}$ and $f(1) = 7$ then $\sum_{r=1}^{n} f(r)$ is

 [A] $\dfrac{7(n + 1)}{2}$
 [B] $\dfrac{7n}{2}$
 [C] $\dfrac{7n(n + 1)}{2}$
 [D] $7n(n + 1)$

56. 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] $-\pi$

[B] $-\dfrac{\pi}{2}$

[C] $\dfrac{\pi}{2}$

[D] 0

57. The remainder when 2^{2020} is divided by 31 is

[A] 5

[B] 3

[C] 1

[D] 7

58. If $A = \begin{bmatrix} i & -i \\ -i & i \end{bmatrix}$ and $B = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$ then A^{2n} is equal to

[A] $(-1)^n 2^{2n-1} B$

[B] $(-1)^n 2^{2n} B$

[C] $(-1)^n 2^n B$

[D] $(-1)^n 2^{2n+1} B$

59. In the binomial expansion of $(a - b)^n, n \geq 0$, if the sum of 5th and 6th terms is zero then $\dfrac{a}{b}$ is equal to

[A] $\dfrac{5}{n - 4}$

[B] $\dfrac{n - 4}{5}$

[C] $\dfrac{6}{n - 5}$

[D] $\dfrac{n - 5}{6}$

60. The number of integer values of k, for which the equation $4 \cos x - 3 \sin x = 2k - 3$ has a solution; is

[A] 6

[B] 5

[C] 7

[D] 4

61. If $f_k(x) = \dfrac{1}{k}(\sin^k x + \cos^k x)$, for all $x \in \mathbb{R}$ and $k \geq 1$, then $f_4(x) - f_6(x)$ is equal to

    [A] $\dfrac{1}{6}$

    [B] $\dfrac{1}{3}$

    [C] $\dfrac{1}{4}$

    [D] $\dfrac{1}{12}$

62. The largest interval for which $x^{12} - x^9 + x^4 - x + 1 > 0$ is

    [A] $-4 < x \leq 0$
    [B] $0 < x < 1$
    [C] $-\infty < x < \infty$
    [D] $-100 < x < 100$

63. Let a straight line L have intercepts a and b on the coordinate axes X and Y, respectively. If the axes are rotated through a given angle, keeping the origin fixed, the same line L has intercepts p and q on the axes X and Y, respectively then

    [A] $a^2 + b^2 = p^2 + q^2$

    [B] $\dfrac{1}{a^2} + \dfrac{1}{b^2} = \dfrac{1}{p^2} + \dfrac{1}{q^2}$

    [C] $a^2 + p^2 = b^2 + q^2$

    [D] $\dfrac{1}{a^2} + \dfrac{1}{p^2} = \dfrac{1}{b^2} + \dfrac{1}{q^2}$

64. If the circles $x^2 + y^2 + 5x - 6y - 1 = 0$ and $x^2 + y^2 + ax - y + 1 = 0$ intersect orthogonally then the value of a is

    [A] $\dfrac{6}{5}$

    [B] $\dfrac{5}{6}$

    [C] $-\dfrac{6}{5}$

    [D] $-\dfrac{5}{6}$

65. The number of words that can be formed using the letters of the word EXAMINATION that start as well as end with N is

[A] $\dfrac{10!}{2!2!}$

[B] $\dfrac{9!}{2!2!}$

[C] $\dfrac{10!}{2!}$

[D] $\dfrac{9!}{2!}$

66. Let $I_n = \displaystyle\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \cot^n x \, dx$. Then $I_2 + I_4, I_3 + I_5, I_4 + I_6, I_5 + I_7, \dots$ are in

[A] Arithmetic Progression
[B] Geometric Progression
[C] Harmonic Progression
[D] no Progression

67. A letter is taken at random from the letters of the word MATHEMATICS and also a letter is taken at random from the letters of the word STATISTICS. The probability that they are the same letter is

[A] $\dfrac{7}{55}$

[B] $\dfrac{13}{110}$

[C] $\dfrac{6}{55}$

[D] $\dfrac{3}{22}$

68. Let $[x]$ denote the greatest integer less than or equal to x. Then $\lim\limits_{x \to a} \left((a-x) + [x-a] + |a-x| \right)$

[A] is equal to 0
[B] is equal to a
[C] is equal to $-a$
[D] does not exist

w-1

69. The value of $f(\frac{\pi}{4})$, such that the function $f(x) = \dfrac{\sin x - \cos x}{\cos 2x}$ is continuous everywhere, is

[A] $-\dfrac{1}{\sqrt{2}}$

[B] $\sqrt{2}$

[C] $-\sqrt{2}$

[D] $\dfrac{1}{\sqrt{2}}$

70. The normal to the circle $x^2 + y^2 - 2x - 2y = 0$ passing through $(2, 2)$ is

[A] $2x + y - 6 = 0$

[B] $x = y$

[C] $x + 2y - 6 = 0$

[D] $x + y - 4 = 0$

71. If f is the inverse of a function g and $g'(x) = \dfrac{2}{x^2 + 1}$ then $f'(x)$ is equal to

[A] $\dfrac{x^2 + 1}{2}$

[B] x

[C] $\dfrac{2}{(f(x))^2 + 1}$

[D] $\dfrac{(f(x))^2 + 1}{2}$

72. $\displaystyle\int \sec^{-1} \sqrt{x}\,dx$ is equal to

[A] $x\sec^{-1}\sqrt{x} - \log(1 + x) + C$

[B] $\sec^{-1}\sqrt{x} - \tan^{-1}\sqrt{x} + C$

[C] $x\sec^{-1}\sqrt{x} - \sqrt{x - 1} + C$

[D] $x\sec^{-1}\sqrt{x} + \sqrt{x + 1} + C$

73. $\displaystyle\int_{\frac{\pi}{6}}^{\frac{\pi}{2}} \dfrac{dx}{1 + \sqrt{\cot x}}$ is equal to

[A] $\dfrac{\pi}{12}$

[B] $\dfrac{\pi}{6}$

[C] $\dfrac{\pi}{4}$

[D] $\dfrac{\pi}{3}$

W-1

74. If $\bar{a} = (\bar{i} - \bar{j} + \bar{k})$ such that $\bar{a} \cdot \bar{b} = -1$ and $\bar{a} \times \bar{b} = \bar{i} - \bar{k}$ then $\bar{b}$ is

[A] $-\dfrac{1}{3}(3\bar{i} + \bar{j} + \bar{k})$

[B] $-\dfrac{1}{3}(2\bar{i} + \bar{j} + 2\bar{k})$

[C] $-\bar{i} + \bar{j} + \bar{k}$

[D] $-\bar{i} + 3\bar{j} - 3\bar{k}$

75. If the functions $f, g : \mathbb{R} \to \mathbb{R}$ are defined as,

$$f(x) = \begin{cases} 0, & \text{if } x \text{ is rational,} \\ x, & \text{if } x \text{ is irrational,} \end{cases} \quad \text{and} \quad g(x) = \begin{cases} 0, & \text{if } x \text{ is irrational,} \\ x, & \text{if } x \text{ is rational,} \end{cases}$$

then the function $(f - g)$ is

[A] one-one but not onto
[B] onto but not one-one
[C] one-one and onto
[D] neither one-one nor onto

ω -1

PHYSICS

76. A car travels from the origin along the positive x-axis for 30 minutes with a speed of 60 kilo-meters/hour (kmph), and then for the next 20 minutes along the positive y-axis with a speed of 120 kmph. What is the magnitude of the average velocity for this journey (in kmph)?

[A] 50.4
[B] 70
[C] 84
[D] 60

77. To open a heavy door, keeping the applied force to a minimum, the force should be Applied

[A] close to the hinge at an angle of 90° to the plane of the door.
[B] far from the hinge at an angle of 90° to the plane of the door.
[C] close to the hinge at an angle of 45° to the plane of the door.
[D] far from the hinge at an angle of 45° to the plane of the door.

78. A block of mass M, attached to a spring, is executing a simple harmonic motion with a period of 2 seconds. If the mass is increased by 2 kilograms, the period increases by 1 second. The value of M is (in kilograms)

[A] 0.44
[B] 1.6
[C] 4.0
[D] 0.8

79. Two balls of masses m_1 and m_2 have the same kinetic energy. If $m_1 > m_2$, which of the following is valid for the respective momenta P_1 and P_2 ?

[A] $P_1 = P_2$
[B] $P_1 \leq P_2$
[C] $P_1 < P_2$
[D] $P_1 > P_2$

80. The drag force on a particle, falling through air, is proportional to the square of the speed. The dimension of the proportionality constant is (in terms of Kg=kilo-gram, m=meter, s=second)

[A] $Kgm^{-1}s^{-1}$
[B] Kgs^{-2}
[C] Kgm^{-1}
[D] $Kgm^{-1}s^{-2}$

PHYSICS

81. A particle P of mass m is moving along the positive x direction with velocity v, towards a stationary particle Q of equal mass. The respective velocities of P and Q with respect to the center of mass are

   [A] $v/2, -v/2$
   [B] $-v/2, v/2$
   [C] $0, v$
   [D] $v, 0$

82. A particle of mass m, lying on a frictionless table, is connected to a wall by a spring. When the particle is given an initial velocity v, at   the equilibrium position, the maximum change in the length of the spring is A. Repeating the same on a table with friction, it is seen that the maximum change in the length of the spring is $A/2$. The energy lost due to the friction is

   [A] $3mv^2/4$
   [B] $mv^2/3$
   [C] $3mv^2/8$
   [D] $3mv^2/5$

83. Consider two sinusoidal wave forms given as $y_1 = A \sin x$, and $y_2 = \frac{A}{2} \sin 2x$ where A is a constant. The amplitude of the superposition $y = y_1 + y_2$ is

   [A] $3A/4$
   [B] $3A/2$
   [C] $3\sqrt{3}A/4$
   [D] A

84. Light rays with four different colours, namely red, green, blue and violet are passed through a narrow single slit. Which colour will be diffracted by the maximum angle with respect to the initial direction?

   [A] red
   [B] green
   [C] blue
   [D] violet

85. A spherical underwater air bubble is illuminated with light. The bubble will act like a

   [A] convex lens
   [B] concave lens
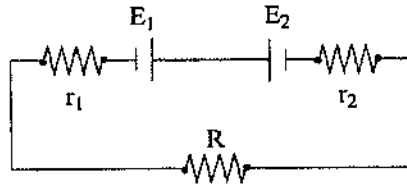   [C] convex mirror
   [D] concave mirror

PHYSICS

86. In the study of the photoelectric effect, the stopping potential for a particular metal depends on

    [A] the intensity of the incident light
    [B] the frequency of the incident light
    [C] both the intensity and the frequency of the incident light
    [D] neither the intensity nor the frequency of the incident light

87. The Lyman series in the hydrogen spectra corresponds to the transitions from the higher energy levels to the ground state. Given that $\pi^2 m e^4 / 2\varepsilon_0^2 h^2 = 21.76 \times 10^{-19} J$, $h = 6.625 \times 10^{-34} J.s$, $c = 3 \times 10^8 m.s^{-1}$, the longest wavelength of the spectral lines in the Lyman series of the hydrogen atom approximately is (in Angstrom)

    [A] 1028
    [B] 1128
    [C] 1218
    [D] 1328

88. A capacitor of capacitance C discharges through a resistance R. The time taken for the capacitor charge to reduce to one-half of its initial value is approximately,

    [A] 0.7 RC
    [B] 0.5 RC
    [C] 0.3 RC
    [D] RC

89. The electric current i in a circuit varies with time t as $i = i_0(sin \, \omega t + sin \, 4\omega t)$, where i_0 and ω are constants. The rms current is

    [A] $|i_0|$
    [B] 0
    [C] $|i_0|/\sqrt{2}$
    [D] $2|i_0|$

90. A neutral conducting spherical shell of inner radius a and outer radius b has a charge q at a distance of $a/2$ from the center. Which of the following is true for the respective charge densities σ_a and σ_b the two spherical surfaces?

    [A] σ_a and σ_b are uniform
    [B] σ_a is uniform and σ_b is non-uniform
    [C] σ_a is non-uniform and σ_b is uniform
    [D] σ_a and σ_b are non-uniform

PHYSICS

91. Two emf sources with $E_1 = 5V$ and $E_2 = 10V$, with the respective internal resistances $r_1 = 3\Omega$ and $r_2 = 2\Omega$ connected through a resistance $R = 5\Omega$ as shown. The current that is passing through the circuit is (in Ampere)

    [A] 1.0
    [B] 3.5
    [C] 5.0
    [D] 0.5

92. Consider an alternating current AC or a direct current DC in connection with a circuit with a capacitor C or an inductor L. Which of the following is true?

    [A] C blocks AC but not DC, and L blocks DC but not AC
    [B] C blocks DC but not AC, and L blocks AC but not DC
    [C] C and L block AC but not DC
    [D] C and L block DC but not AC

93. Consider an ideal gas in a container with the gas molecules having a root mean square (rms) speed of v. If the gas is compressed to half of its initial volume keeping the pressure constant, the rms speed of the molecules is

    [A] $\sqrt{2}v$
    [B] $2v$
    [C] $v/\sqrt{2}$
    [D] $v/2$

94. An ideal gas undergoes a quasistatic thermodynamic process. During the process, the internal energy of the ideal gas decreases by the same amount as the work done by the gas. Which of the following is true?

    [A] It is an adiabatic process that increases the temperature
    [B] It is an adiabatic process that decreases the temperature
    [C] It is an isothermal process that increases the entropy
    [D] It is an isothermal process that decreases the entropy

95. A fire engine raises 1200 litres of water per minute through a height of 2 metres an discharges it with a velocity of 12 m/sec. Given that the density of water is one gram/cubic-centimeter, the power delivered by the fire engine approximately is (in watt)

    [A] 1440
    [B] 1480
    [C] 1680
    [D] 1840

PHYSICS

96. A vertical column with a uniform area of cross-section of height h contains a liquid. The density of the liquid varies linearly with the height, with the density ρ_a at the top of the column, and a density of ρ_b at the bottom of the column. The difference between the pressures at the bottom and the top is
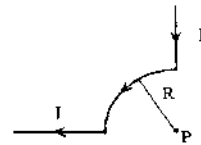
   [A] $(\rho_a + \rho_b)gh/2$
   [B] $\sqrt{\rho_a \rho_b} gh$
   [C] $(\rho_a - \rho_b)gh$
   [D] $\rho_a \rho_b gh/(\rho_a + \rho_b)$

97. A force of $3.142 \times 10^5 N$ is applied along the length of a copper wire of radius 10 milli-metres and length 100 centi-meters. The stress in the wire approximately is (in SI units)

   [A] 10^7
   [B] 10^5
   [C] 10^3
   [D] 10^9

98. A very long wire, consisting of a long straight section, a quarter-circle of radius R, and another long straight section, is carrying a current I as shown in the figure. The magnitude and direction of the magnetic field B at the point P (the center of the circle) are

   [A] $\mu_0 I/8R$, out of the page
   [B] $\mu_0 I/4R$, out of the page
   [C] $\mu_0 I/8R$, into the page
   [D] $\mu_0 I/4R$, into the page

99. When a pressure is applied to a material, there is a fractional change of volume that depends on the bulk modulus. Which of the following is true for the respective bulk moduli of steel and water B_s and B_w ?

   [A] $B_s > 0, B_w < 0$
   [B] $B_s < 0, B_w > 0$
   [C] $B_s > B_w > 0$
   [D] $0 > B_s > B_w$

100. On turning a corner, a motorist traveling with a velocity of 36 kilometers per hour finds a child at distance of 51 meters. He stops the car within 1 meter of the child by applying the brakes. Given that the total weight of the car with the driver is 2000 kilograms, the force applied to stop the car is (in Newton)

   [A] 2000
   [B] 4000
   [C] 3921.57
   [D] 32400