JEE(Main)-2026_Phase-1_(28-01-2026)_Morning_Paper

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE is correct.

Choose the correct answer:

1. For three unit vectors $\vec{a},\vec{b},\vec{c}$ satisfying
$|\vec{a}-\vec{b}|^2+|\vec{b}-\vec{c}|^2+|\vec{c}-\vec{a}|^2=9$ and $|2\vec{a}+k\vec{b}+k\vec{c}|=3$, the positive value of k is
(1) 6
(2) 4
(3) 3
(4) 5

2. Let A,B and C be three 2×2 matrices with real entries such that $B=(I+A)^{-1}$ and A + C = I.

If BC $=\begin{bmatrix}1 & -5\\ -1 & 2\end{bmatrix}$ and CB $\begin{bmatrix}x_1\\ x_2\end{bmatrix}=\begin{bmatrix}12\\ -6\end{bmatrix}$, then x_1+x_2 is
(1) -2
(2) 4
(3) 0
(4) 2

3. A bag contains 10 balls out of which k are red and $(10-k)$ are black, where $0\le k\le 10$. If three balls are drawn at random without replacement and all of them are found to be black, then the probability that the bag contains 1 red and 9 black balls is:
(1) $\frac{7}{55}$
(2) $\frac{7}{110}$
(3) $\frac{7}{11}$
(4) $\frac{14}{55}$

4. The value of

$$\lim_{x\to 0}\frac{\log_e\left(\sec(ex)\cdot\sec\left(e^2x\right)\cdot\ldots\cdot\sec\left(e^{10}x\right)\right)}{e^2-e^{2\cos x}}$$

is equal to

(1) $\frac{\left(e^{10}-1\right)}{2e^2\left(e^2-1\right)}$

(2) $\frac{\left(e^{20}-1\right)}{2e^2\left(e^2-1\right)}$

(3) $\frac{\left(e^{10}-1\right)}{2\left(e^2-1\right)}$

(4) $\frac{\left(e^{20}-1\right)}{2\left(e^2-1\right)}$

5. Let ABC be an equilateral triangle with orthocenter at the origin and the side BC on the line $x+2\sqrt{2}y=4$. If the co-ordinates of the vertex A are (α,β), then the greatest integer less than or equal to $|\alpha+\sqrt{2}\beta|$ is

(1) 5

(2) 4

(3) 3

(4) 2

6. Let $S=\{1,2,3,4,5,6,7,8,9\}$. Let x be the number of 9-digit numbers formed using the digits of the set S such that only one digit is repeated and it is repeated exactly twice. Let y be the number of 9-digit numbers formed using the digits of the set S such that only two digits are repeated and each of these is repeated exactly twice. Then,

(1) $45x=7y$

(2) $29x=5y$

(3) $56x=9y$

(4) $21x=4y$

7. If $g(x)=3x^2+2x-3, f(0)=-3$ and $4g(f(x))=3x^2-32x+72$, then $f(g(2))$ is equal to:

(1) $-\frac{7}{2}$

(2) $\frac{7}{2}$

(3) $\frac{25}{6}$

(4) $-\frac{25}{6}$

8. The common difference of the A.P.: $a_1,a_2,\ldots,a_m$ is 13 more than the common difference of the A.P.: $b_1,b_2,\ldots,b_n$. If $b_{31}=-277, b_{43}=-385$ and $a_{78}=327$, then a_1 is equal to

(1) 19

(2) 16

(3) 21

(4) 24

9. Let f be a polynomial function such that $f\left(x^2+1\right)=x^4+5x^2+2$, for all $x\in\mathbb{R}$.

Then $\int_0^3 f(x)dx$ is equal to
(1) $\frac{41}{3}$
(2) $\frac{33}{2}$
(3) $\frac{5}{3}$
(4) $\frac{25}{3}$

10. Let z be a complex number such that $|z-6|=5$ and $|z+2-6i|=5$. Then the value of $z^3+3z^2-15z+141$ is equal to
(1) 50
(2) 61
(3) 42
(4) 37

11. If the distances of the point $(1,2,a)$ from the line $\frac{x-1}{1}=\frac{y}{2}=\frac{z-1}{1}$ along the lines
$L_1: \frac{x-1}{3}=\frac{y-2}{4}=\frac{z-a}{b}$ and
$L_2: \frac{x-1}{1}=\frac{y-2}{4}=\frac{z-a}{c}$ are equal, then $a+b+c$ is equal to
(1) 7
(2) 4
(3) 6
(4) 5

12. Let $S=\left\{x^3+ax^2+bx+c: a,b,c\in\mathbb{N} \text{ and } a,b,c\le 20\right\}$ be a set of polynomials.
Then the number of polynomials in S, which are divisible by x^2+2, is
(1) 10
(2) 20
(3) 120
(4) 6

13. If α,β, where $\alpha<\beta$, are the roots of the equation $\lambda x^2-(\lambda+3)x+3=0$ such that $\frac{1}{\alpha}-\frac{1}{\beta}=\frac{1}{3}$, then the sum of all possible values of λ is
(1) 2
(2) 8
(3) 4
(4) 6

14. The value of $\sum_{k=1}^{\infty}(-1)^{k+1}\left(\frac{k(k+1)}{k!}\right)$ is
(1) $e/2$
(2) $2/e$
(3) $1/e$
(4) $\sqrt{e}$

15. If $\frac{\tan(A-B)}{\tan A}+\frac{\sin^2 C}{\sin^2 A}=1, A,B,C\in\left(0,\frac{\pi}{2}\right)$, then
(1) $\tan A, \tan C, \tan B$ are in A.P.
(2) $\tan A, \tan B, \tan C$ are in A.P.
(3) $\tan A, \tan B, \tan C$ are in G.P.
(4) $\tan A, \tan C, \tan B$ are in G.P.

16. The mean and variance of 10 observations are 9 and 34.2, respectively. If 8 of these observations are 2,3,5,10,11,13,15,21, then the mean deviation about the median of all the 10 observations is
(1) 5
(2) 7
(3) 4
(4) 6

17. If $\int\left(\frac{1-5\cos^2 x}{\sin^5 x\cos^2 x}\right)dx=f(x)+C$, where C is the constant of integration, then $f\left(\frac{\pi}{6}\right)-f\left(\frac{\pi}{4}\right)$ is equal to
(1) $\frac{1}{\sqrt{3}}(26+\sqrt{3})$
(2) $\frac{2}{\sqrt{3}}(4+\sqrt{6})$
(3) $\frac{4}{\sqrt{3}}(8-\sqrt{6})$
(4) $\frac{1}{\sqrt{3}}(26-\sqrt{3})$

18. The area of the region
$R=\left\{(x,y): xy\le 8, 1\le y\le x^2, x\ge 0\right\}$ is
(1) $\frac{2}{3}\left(20\log_e(2)+9\right)$
(2) $\frac{2}{3}\left(24\log_e(2)-7\right)$
(3) $\frac{1}{3}\left(49\log_e(2)-15\right)$
(4) $\frac{1}{3}\left(40\log_e(2)+27\right)$

Answer (2)

19. Let $y=y(x)$ be the solution of the differential equation $x\frac{dy}{dx}-\sin 2y=x^3\left(2-x^3\right)\cos^2 y, x\neq 0$. If $y(2)=0$, then $\tan(y(1))$ is equal to
(1) $\frac{3}{4}$
(2) $\frac{7}{4}$
(3) $-\frac{3}{4}$
(4) $-\frac{7}{4}$

Answer (2)

20. Let $y=x$ be the equation of a chord of the circle C_1 (in the closed half-plane $x\ge 0$) of diameter 10 passing through the origin. Let C_2 be another circle described on the given

chord as its diameter. If the equation of the chord of the circle C_2, which passes through the point (2,3) and is farthest from the center of C_2, is $x + ay + b = 0$, then $a - b$ is equal to
(1) 6
(2) -6
(3) 10
(4) -2

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. If $k = \tan\left(\frac{\pi}{4} + \frac{1}{2}\cos^{-1}\left(\frac{2}{3}\right)\right) + \tan\left(\frac{1}{2}\sin^{-1}\left(\frac{2}{3}\right)\right)$, then the number of solutions of the equation $\sin^{-1}(kx - 1) = \sin^{-1} x - \cos^{-1} x$ is ____
Answer (1)

22. Let PQR be a triangle such that $\overrightarrow{PQ} = -2\hat{i} - \hat{j} + 2\hat{k}$ and $PR = a\hat{i} + b\hat{j} - 4\hat{k}, a,b \in \mathbb{Z}_1$. Let S be the point on QR, which is equidistant from the lines PQ and PR. If $|\overrightarrow{PR}| = 9$ and $\overrightarrow{PS} = \hat{i} - 7\hat{j} + 2\hat{k}$, then the value of $3a - 4b$ is ____

24. For some $\theta \in \left(0, \frac{\pi}{2}\right)$, let the eccentricity and the length of the latus rectum of the hyperbola $x^2 - y^2\sec^2\theta = 8$ be e_1 and l_1, respectively, and let the eccentricity and the length of the latus rectum of the ellipse $x^2\sec^2\theta + y^2 = 6$ be e_2 and l_2, respectively. If $e_1^2 = e_2^2\left(\sec^2\theta + 1\right)$, then $\left(\frac{l_1 l_2}{e_1 e_2}\right)\tan^2\theta$ is equal to ____

25. In a G.P., if the product of the first three terms is 27 and the set of all possible values for the sum of its first three terms is $\mathbb{R} - (a,b)$, then $a^2 + b^2$ is equal to ____ .

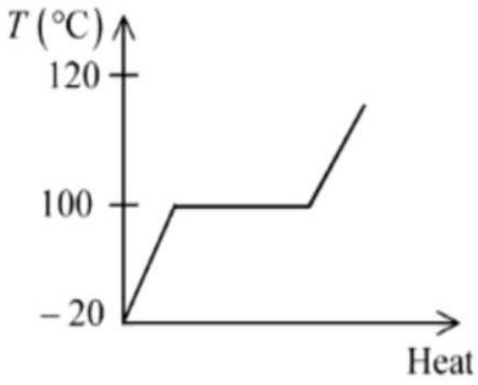
PHYSICS

SECTION - A

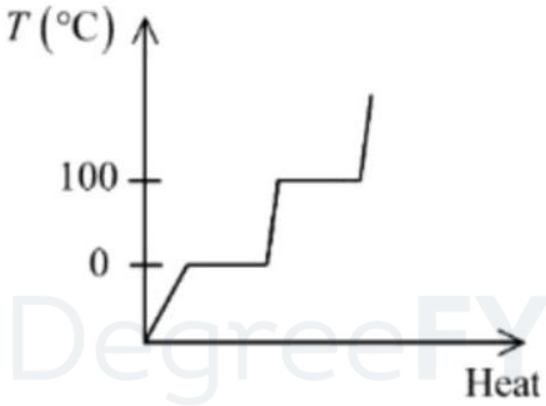
Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE is correct.

Choose the correct answer :

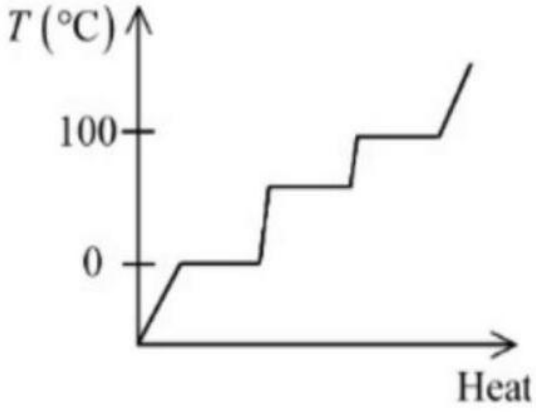
26. Which of the following best represents the temperature versus heat supplied graph for water, in the range of $-20^\circ C$ to $120^\circ C$?
(1)



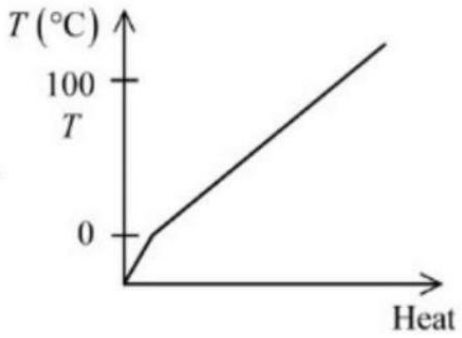
(2)



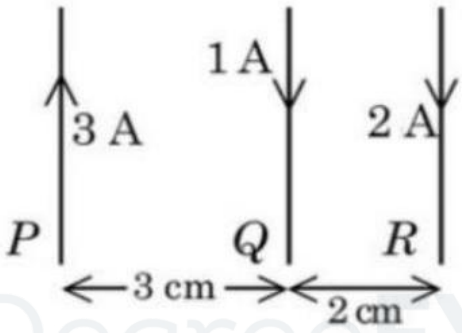
(3)



(4)



27. Three long straight wires carrying current are arranged mutually parallel as shown in the figure. The force experienced by 15 cm length of wire Q is ____ .



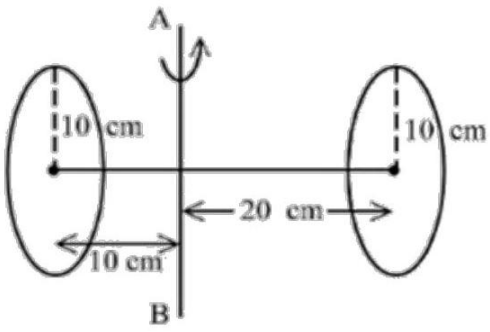
$\left(\mu_o = 4\pi \times 10^{-7}\ \text{T.m/A}\right)$
(1) 6×10^{-6} N towards P
(2) 6×10^{-6} N towards R
(3) 6×10^{-7} N towards R
(4) 6×10^{-7} N towards P

28. The electric current in the circuit is given as $i = i_o(t/T)$. The r.m.s current for the period $t = 0$ to $t = T$ is ____ .
(1) $\frac{i_o}{\sqrt{2}}$
(2) i_0
(3) $\frac{i_o}{\sqrt{3}}$
(4) $\frac{i_o}{\sqrt{6}}$

29. The magnitudes of power of a biconvex lens (refractive index 1.5) and that of a plano-concave lens (refractive index = 1.7) are same. If the curvature of planoconcave lens exactly matches with the curvature of back surface of the biconvex lens, then ratio of radius of curvature of front and back surface of the biconvex lens is ____.
(1) 2:5
(2) 12:5
(3) 5:12
(4) 5:2

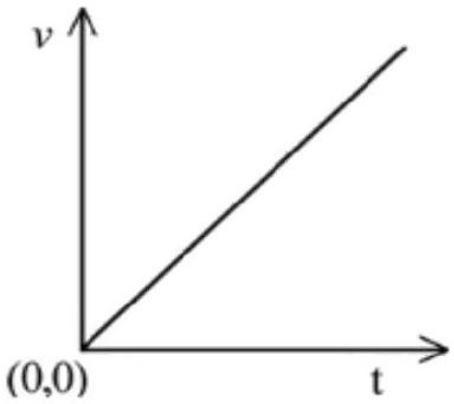
30. Two circular discs of radius each 10 cm are joined at their centres by a rod of length 30 cm and mass 600 gm as shown in figure.

If the mass of each disc is 600 gm and applied torque between two discs is 43×10^5 dyne. cm , the angular acceleration of the discs about the given axis AB is ____ rad/s^2.

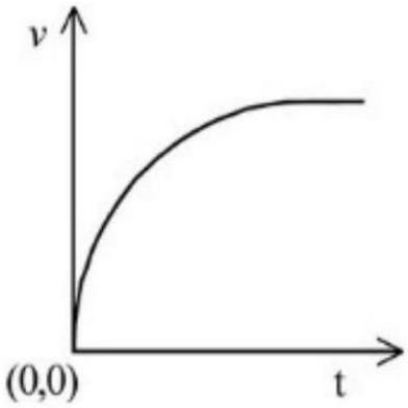


(1) 11
(2) 22
(3) 27
(4) 100

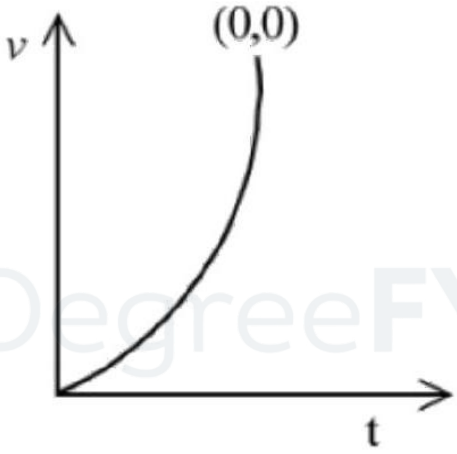
31. A particle of mass m falls from rest through a resistive medium having resistive force, $F = -kv$, where v is the velocity of the particle and k is a constant. Which of the following graphs represents velocity (v) versus time (t)?
(1)



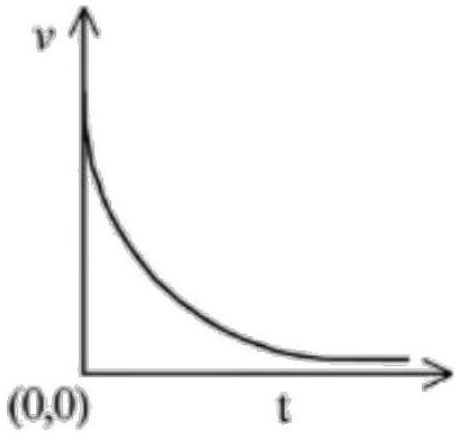
(2)



(3)



(4)



32. For the two cells having same EMF E and internal resistance r, the current passing through the external resistor 6Ω is same when both the cells are connected either in parallel or in series. The value of internal resistance r is ____ Ω.

(1) 6
(2) 3
(3) 9
(4) 4

33. Two point charges of 1 nC and 2 nC are placed at the two corners of equilateral triangle of side 3 cm . The work done in bringing a charge of 3 nC from infinity to the third corner of the triangle is ____ μJ.

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N} \cdot \text{ m}^2/\text{C}^2$$

(1) 27
(2) 5.4
(3) 3.3
(4) 2.7

34. Given below are two statements:

Statement I: A plane wave after passing through prism remains as plane wave but passing through small pin hole may become spherical wave.

Statement II: The curvature of a spherical wave emerging from a slit will increase for increasing slit width.

In the light of the above statements, choose the correct answer from the options given below
(1) Statement I is false but Statement II is true
(2) Both Statement I and Statement II are false
(3) Both Statement I and Statement II are true
(4) Statement I is true but Statement II is false

35. The magnetic field at the centre of a current carrying circular loop of radius R is $16\mu T$. The magnetic field at a distance $x = \sqrt{3}R$ on its axis from the centre is ____ μT.
(1) 8
(2) 2
(3) $2\sqrt{2}$
(4) 4

36. In the potentiometer, when the cell in the secondary circuit is shunted with 4Ω resistance, the balance is obtained at the length 120 cm of wire. Now when the same cell is shunted with 12Ω resistance, the balance is shifted to a length of 180 cm . The internal resistance of cell is ____ Ω
(1) 12
(2) 4
(3) 6
(4) 3

37. An atom ${}^{8}_{3}X$ is bombarded by shower of fundamental particles and in 10 s this atom absorbed 10 electrons, 10 protons and 9 neutrons. The percentage growth in the surface area of the nucleons is recorded by
(1) 900%

(2) 250%
(3) 150%
(4) 225%

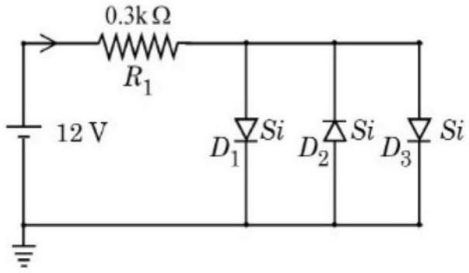
38. When both jaws of vernier callipers touch each other, zero mark of the vernier scale is right to zero mark of main scale, 4^{th} mark on vernier scale coincides with certain mark on the main scale. While measuring the length of a cylinder, observer observes 15 divisions on main scale and 5^{th} division of vernier scale coincides with a main scale division. Measured length of cylinder is ____ mm.
(Least count of Vernier calliper = 0.1 mm)
(1) 15.4
(2) 15.1
(3) 15.5
(4) 15.9

39. A block of mass 5 kg is moving on an inclined plane which makes an angle of 30° with the horizontal. Friction coefficient between the block and inclined plane surface is $\frac{\sqrt{3}}{2}$. The force to be applied on the block so that the block will move down without acceleration is ____ N.
$\left(g = 10 \text{ m/s}^2\right)$.
(1) 7.5
(2) 15
(3) 25
(4) 12.5

40. Two wires A and B made of different materials of lengths 6.0 cm and 5.4 cm , respectively and area of cross sections 3.0×10^{-5} m^2 and 4.5×10^{-5} m^2, respectively are stretched by the same magnitude under a given load. The ratio of the Young's modulus of A to that of B is x:3. The value of x is
____ .
(1) 2
(2) 1
(3) 5
(4) 4

41. 10 kg of ice at – 10°C is added to 100 kg of water to lower its temperature from 25°C. Consider no heat exchange to surroundings. The decrement to the temperature of water is ____ °C.
(specific heat of ice = 2100 J/Kg. °C, specific heat of water = 4200 J/Kg. °C, latent heat of fusion of ice = 3.36×10^5 J/Kg)
(1) 10
(2) 11.6
(3) 15
(4) 67

42. Assuming in forward bias condition there is a voltage drop of 0.7 V across a silicon diode, the current through diode D_1 in the circuit is ____ mA .
(Assume all diodes in the given circuit are identical)?

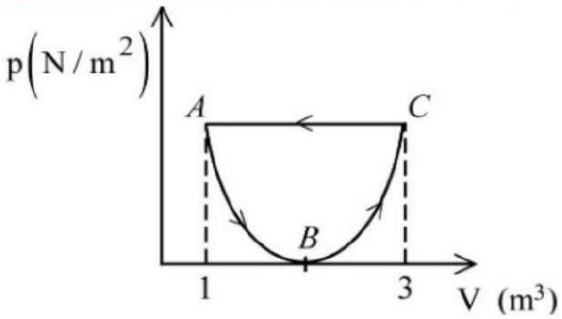


(1) 17.6
(2) 18.8
(3) 20.15
(4) 11.7

43. Water drops fall from a tap on the floor, 5 m below, at regular intervals of time, the first drop strikes the floor when the sixth drop begins to fall. The height at which the fourth drop will be from ground, at the instant when the first drop strikes the ground is
____ m.
($g = 10\ m/s^2$)
(1) 2.5
(2) 4.2
(3) 4.0
(4) 3.8

44. The electric field of an electromagnetic wave travelling through a medium is given by $\vec{E}(x,t) = 25\sin\left(2.0\times10^{15}t - 10^{7}x\right)\hat{n}$ then the refractive index of the medium is ____ .
(All given measurement are in SI units)?
(1) 1.7
(2) 1.2
(3) 1.5
(4) 2

45. In the following $p - V$ diagram the equation of state along the curved path is given by $(V-2)^2 = 4$ ap where a is a constant. The total work done in the closed path is



(1) $-\frac{1}{3a}$
(2) $-\frac{1}{a}$

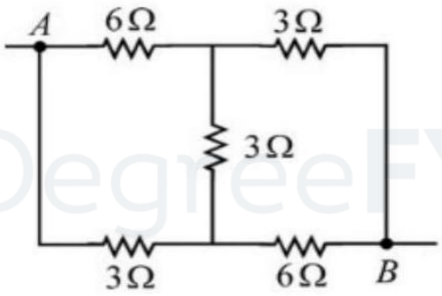
(3) $+\frac{1}{3a}$
(4) $\frac{1}{2a}$

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

46. A convex lens of refractive index 1.5 and focal length $f = 18$ cm is immersed in water. The difference in focal lengths of the given lens when it is in water and in air is $\alpha \times f$. The value of α is ____ . (refractive index of water = 4/3)

47. The equivalent resistance between the points A and B in the following circuit is $\frac{x}{5}\Omega$. The value of x is ____ .



48. The displacement of a particle, executing simple harmonic motion with time period T, is expressed as $x(t) = A\sin \omega t$, where A is the amplitude. The maximum value of potential energy of this oscillator is found at $t = T/2\beta$. The value of β is ____ .

49. A solid sphere of radius 10 cm is rotating about an axis which is at a distance 15 cm from its centre. The radius of gyration about this axis is $\sqrt{n}$ cm. The value of n is

50. The ratio of de Broglie wavelength of a deutron with kinetic energy E to that of an alpha particle with kinetic energy $2E$, is n:1. The value of n is ____ .
(Assume mass of proton = mass of neutron) :

CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE is correct.

Choose the correct answer :

51. Given below are the four isomeric compounds (P, Q, R, S)



(P)





(Q)



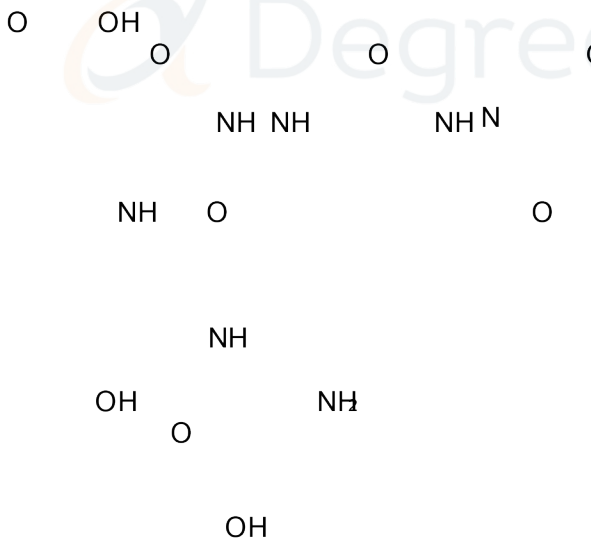
(R)



(S)

Identify correct statements from below.
A. *Q*,*R* and *S* will give precipitate with 2,4-DNP.
B. P and Q will give positive Bayer's test.
C. *Q* and *R* will give sooty flame.
D. *R* and *S* will give yellow precipitate with I_2/NaOH.
E. Q alone will deposit silver with Tollen's reagent Choose the correct option.
(1) A and E only
(2) C and E only
(3) A, B, D and E only
(4) A, C and E only

52. In the given pentapeptide, find out an essential amino acid (Y) and the sequence present in the pentapeptide:



(1)

(Y)	(Sequence)
Serine	Thr-Ser-Asp-Ala-Gly

(2)

(Y)	(Sequence)
Threonine	Thr-Ser-Asp-Gly-Ala

(3)

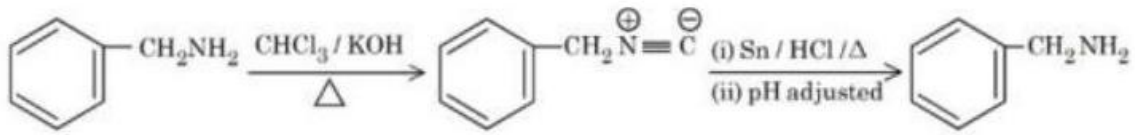
(Y)	(Sequence)
Threonine	Ser-Thr-Asp-Gly-Ala

(4)

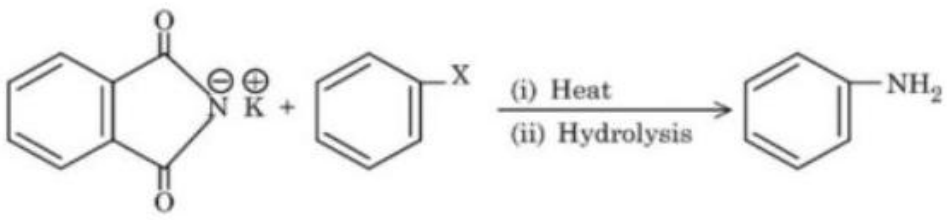
(Y)	(Sequence)
Serine	Ser-Asp-Thr-Ala-Gly

53. In period 4 of the periodic table, the elements with highest and lowest atomic radii are respectively.
(1) K & Se
(2) Rb&Br
(3) Na&Cl
(4) K&Br

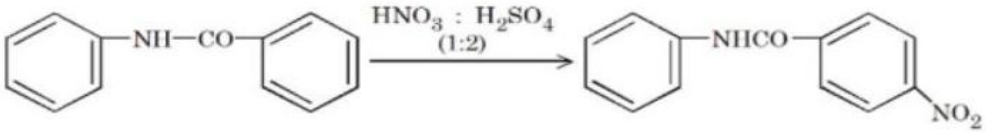
54. Consider the following reactions giving major product. Identify the correct reaction.
(1)



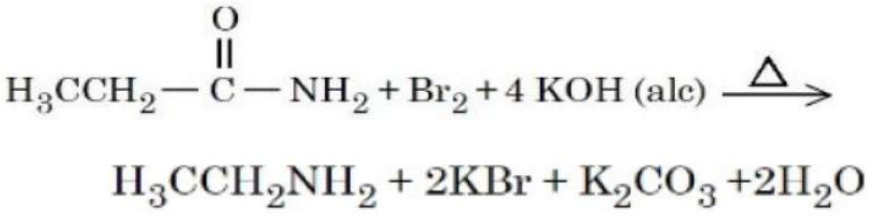
(2)



(3)



(4)



55. Given below are two statements:

Statement I: Griss-llosvay test is used for the detection of nitrite ion, which involves the use of sulphanilic acid and α-naphthylamine reagent.

Statement II: In the above test, sulphanilic acid is diazotized by the acidified nitrite ion, which on further coupling with α-naphthylamine forms an azo-dye.

In the light of the above statements, choose the correct answer from the options given below
(1) Both Statement I and Statement II are false
(2) Statement I is false but Statement II is true
(3) Statement I is true but Statement II is false
(4) Both Statement I and Statement II are true

56. $Ph - CH = CH_2 \xrightarrow[HBr]{(PhCOO)_2}$ Product

Consider the above reaction
A. The reaction proceeds through a more stable radical intermediate.
B. The role of peroxide is to generate $H^{\cdot}$ (Hydrogen radical).
C. During this reaction, benzene is formed as a byproduct.
D. 1-Bromo-2-phenylethane is formed as the minor product.
E. The same reaction in absence of peroxide proceeds via carbocation intermediate.

Identify the correct statements. Choose the correct answer from the options given below:
(1) C, D & E Only
(2) A, C & E Only
(3) A & E Only
(4) A, B & D Only

57. 20.0dm^3 of an ideal gas ' X ' at 600 K and 0.5 MPa undergoes isothermal reversible expansion until pressure of the gas is 0.2 MPa . Which of the following option is correct? (Given: log 2 = 0.3010 and log 5 = 0.6989)
(1) $w = -9.1\ kJ, \Delta U = 0, \Delta H = 0; q = 9.1\ kJ$
(2) $w = +4.1\ kJ, \Delta U = 0, \Delta H = 0; q = -4.1\ kJ$
(3) $w = -3.9\ kJ, \Delta U = 0, \Delta H = 0; q = 3.9\ kJ$
(4) $w = 9.1\ J, \Delta U = 9.1\ J, \Delta H = 0; q = 0$

58. Given below are two statements:

Statement I: The number of species among BF_4^-, SiF_4, XeF_4 and SF_4, that have unequal E – F bond lengths is two. Here, E is the central atom.

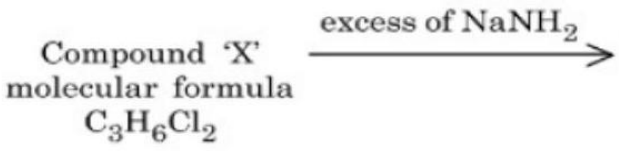
Statement II: Among O_2^-, O_2^{2-}, F_2 and O_2^+, O_2^- has the highest bond order.

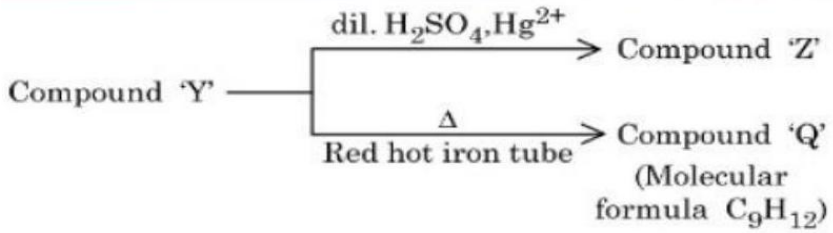
In the light of the above statements, choose the correct answer from the options given below.
(1) Statement I is false but Statement II is true
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are false
(4) Both Statement I and Statement II are true

59. An organic compound undergoes first order decomposition. The time taken for decomposition to $\left(\frac{1}{8}\right)^{th}$ and $\left(\frac{1}{10}\right)^{th}$ of its initial concentration are $\mathbf{t}_{1/8}$ and $\mathbf{t}_{1/10}$ respectively.

What is the value of $\frac{t_{1/8}}{t_{1/10}} \times 10$?(log 2 = 0.3)
(1) 0.9
(2) 30
(3) 9
(4) 3

60. Given below are two statements for the following reaction sequence.





Statement I: Compound 'Z' will give yellow precipitate with NaOI .

Statement II: Compound 'Q' has two different types of ' H ' atoms (aromatic: aliphatic) in the ratio 1:3.

In the light of the above statements, choose the correct answer from the options given below:
(1) Statement I is true but Statement II is false
(2) Both Statement I and Statement II are false
(3) Statement I is false but Statement II is true
(4) Both Statement I and Statement II are true

61. Consider a weak base ' B ' of $pK_b = 5.699$. ' x ' mL of 0.02 M HCl and ' y ' mL of 0.02 M weak base ' B ' are mixed to make 100 mL of a buffer of pH 9 at 25°C. The values of ' x ' and ' y ' respectively are
[Given: log 2 = 0.3010,log 3 = 0.4771,log 5 = 0.699]

(1)

x	y
85.7	14.3

(2)

x	y
42.7	57.3

(3)

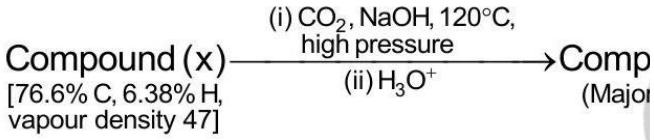
x	y
14.3	85.7

(4)

x	y
11.1	88.9

Answer (3)

62. Consider the following reaction sequence:

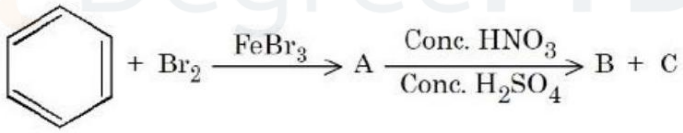


Compound (y) develops characteristic colour with neutral $FeCl_3$ solution.

Identify the INCORRECT statement from the following for the above sequence.
(1) Both compounds *x* and *y* will dissolve in NaOH
(2) Compound y will dissolve in $NaHCO_3$ and evolve a gas
(3) Compound x is more acidic than compound y
(4) Both compounds *x* and *y* will burn with sooty flame

63. The correct statement among the following is:
(1) $Ni(CO)_4$ and $[NiCl_4]^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic.
(2) $Ni(CO)_4$ is diamagnetic and $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic.
(3) $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic.
(4) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $[NiCl_4]^{2-}$ is paramagnetic.

64. Method used for separation of mixture of products (*B* and *C*) obtained in the following reaction is



(1) simple distillation
(2) steam distillation
(3) sublimation
(4) fractional distillation

65. At T(K),2 moles of liquid A and 3 moles of liquid B are mixed. The vapour pressure of ideal solution formed is 320 mm Hg . At this stage, one mole of A and one mole of B are added to the solution. The vapour pressure is now measured as 328.6 mm Hg . The vapour pressure (in mm Hg) of A and B are respectively:
(1) 400, 300
(2) 600,400
(3) 500, 200
(4) 300,200

66. Regarding the hydrides of group 15 elements EH_3(E = N,P,As,Sb), select the correct statement from the following:
A. The stability of hydrides decreases down the group.

B. The basicity of hydrides decreases down the group.
C. The reducing character increases down the group.
D. The boiling point increases down the group.

Choose the correct answer from the options given below:
(1) A, B, C & D
(2) A, B & C only
(3) A & D only
(4) B & C only

67. CORRECT order of stability for the following is

(1) $CH \equiv C^- > CH_2 = CH^- > CH_3 - CH_2^-$
(2) $CH_3 - CH_2^- > CH_2 = CH^- > CH \equiv C^-$
(3) $CH_2 = CH^- > CH \equiv C^- > CH_3 - CH_2^-$
(4) $CH \equiv C^- > CH_3 - CH_2^- > CH_2 = CH^-$

68.

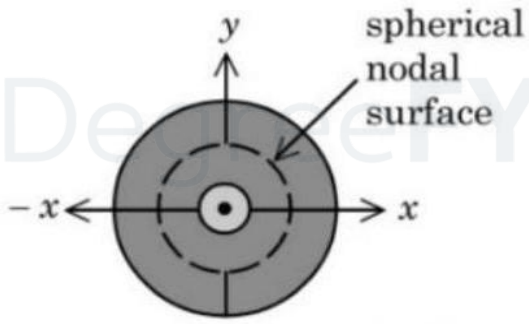


Figure 1. electron probability density for 2s orbital

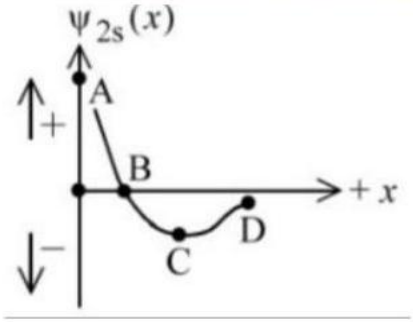


Figure 2. wave function for 2s orbital

Which of the following point in Figure 2 most accurately represents the nodal surface as shown in Figure 1?
(1) A
(2) C

(3) B
(4) D

69. Given below are two statements:

Statement I: The number of pairs, from the following, in which both the ions are coloured in aqueous solution is 3 .
$\left[Sc^{3+}, Ti^{3+}\right]$, $\left[Mn^{2+}, Cr^{2+}\right]$, $\left[Cu^{2+}, Zn^{2+}\right]$ and $\left[Ni^{2+}, Ti^{4+}\right]$
Statement II: Th^{4+} is the strongest reducing agent among $Th^{4+}, Ce^{4+}, Gd^{3+}$ and Eu^{2+}.
In the light of the above statements, choose the correct answer from the options given below.
(1) Both Statement I and Statement II are true
(2) Statement I is false but Statement II is true
(3) Statement I is true but Statement II is false
(4) Both Statement I and Statement II are false

70. The wave numbers of three spectral lines of H atom are considered. Identify the set of spectral lines belonging to Balmer series.
(R = Rydberg constant)
(1) $\frac{3R}{4}, \frac{3R}{16}, \frac{7R}{144}$
(2) $\frac{7R}{144}, \frac{3R}{16}, \frac{16R}{255}$
(3) $\frac{5R}{36}, \frac{3R}{16}, \frac{21R}{100}$
(4) $\frac{5R}{36}, \frac{8R}{9}, \frac{15R}{16}$

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

71. 500 mL of 1.2 M KI solution is mixed with 500 mL of $0.2 M KMnO_4$ solution in basic medium. The liberated iodine was titrated with standard 0.1 M $Na_2S_2O_3$ solution in the presence of starch indicator till the blue color disappeared. The volume (in L) of $Na_2S_2O_3$ consumed is ____ . (Nearest integer)

72. 0.53 g of an organic compound (x) when heated with excess of nitric acid (concentrated) and then with silver nitrate gave 0.75 g of silver bromide precipitate. 1.0 g of (x) gave 1.32 g of CO_2 gas on combustion. The percentage of hydrogen in the compound (x) is ____ %. [Nearest Integer]
[Given: Molar mass in $gmol^{-1}$ H:1,C:12,Br:80, Ag : 108, O : 16; Compound (x):$C_xH_yBr_z$]

73. Consider the dissociation equilibrium of the following weak acid
$HA \rightleftharpoons H^+(aq) + A^-(aq)$
If the pKa of the acid is 4 , then the pH of 10 mMHA solution is ____ . (Nearest integer)
[Given: The degree of dissociation can be neglected with respect to unity]

74. Consider the following redox reaction taking place in acidic medium
$BH_4^-(aq) + ClO_3^-(aq) \longrightarrow H_2BO_3^-(aq) + Cl^-(aq)$

If the Nernst equation for the above balanced reaction is
$E_{cell} = E^{\circ}_{cell} - \frac{RT}{nF} \ln Q$,
then the value of n is ____ . (Nearest integer)

75. X is the number of geometrical isomers exhibited by
$[Pt(NH_3)(H_2O)BrCl]$.
Y is the number of optically inactive isomer(s) exhibited by $[CrCl_2(ox)_2]^{3-}$

Z is the number of geometrical isomers exhibited by $[Co(NH_3)_3(NO_2)_3]$.

The value of $X + Y + Z$ is ____ .

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MATHEMATICS

SECTION – A

1. Answer (4)

Sol. $|\vec{a}| = 1 = |\vec{b}| = |\vec{c}|$

$$|\vec{a} - \vec{b}|^2 = (\vec{a} - \vec{b}) \cdot (\vec{a} - \vec{b})$$
$$= 2 - 2\vec{a} \cdot \vec{b}$$
$$\Rightarrow \sum 2 - 2\vec{a} \cdot \vec{b} = 9$$
$$\Rightarrow \cos\theta_1 + \cos\theta_2 + \cos\theta_3 = -\frac{3}{2}$$
$$\Rightarrow \theta_1 = \theta_2 = \theta_3 = \frac{2\pi}{3}$$
$$\Rightarrow \vec{a} \cdot \vec{b} = -\frac{1}{2}, \vec{b} \cdot \vec{c} = -\frac{1}{2}, \vec{c} \cdot \vec{a} = -\frac{1}{2}$$
$$|2\vec{a} + k\vec{b} + k\vec{c}|^2$$
$$= 4 + k^2 + k^2 + 2\left(2k + 2k + k^2\right)\left(-\frac{1}{2}\right)$$
$$= 2k^2 - 4k + 4 = (k-2)^2 = 9$$
$$\Rightarrow k = 5$$

2. Answer (3)

Sol. $B = (I + A)^{-1}$

$$B^{-1} = I + A$$
$$A + C = I \Rightarrow C = I - A$$
$$BC = (I + A)^{-1}(I - A)$$

$\therefore$ Any polynomial A commutes with any other polynomial in A

$\Rightarrow (I + A)^{-1}(I - A) = (I - A)(I + A)^{-1} \Rightarrow AC = CB$

.

$$CB\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -6 \end{bmatrix}$$
$$\begin{bmatrix} 1 & -5 \\ -1 & 2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -6 \end{bmatrix}$$
$$\left.\begin{aligned} x_1 - 5x_2 &= 12 \\ -x_1 + 2x_2 &= -6 \end{aligned}\right\} x_1 = 2, x_2 = -2$$

$\Rightarrow x_1 + x_2 = 0$

3. Answer (4)

Sol. $P\left(\frac{1R+9B}{BBB}\right) = \frac{P(1R+9B)P\left(\frac{BBB}{1R+9B}\right)}{P(BBB)}$

$$= \frac{\left(\frac{1}{10}\right) \cdot \frac{{}^{9}C_3}{{}^{10}C_3}}{\sum_{k=0}^{10} P\left(\frac{BBB}{kR+(10-k)B}\right) \cdot P(kR+(10-k)B)}$$

$$= \frac{\frac{1}{10} \cdot \frac{{}^{9}C_3}{{}^{10}C_3}}{\frac{1}{10}\sum_{k=0}^{10} \frac{{}^{10-k}C_3}{{}^{10}C_3}} = \frac{{}^{9}C_3}{\sum_{k=0}^{10} {}^{10-k}C_3}$$

$$= \frac{{}^{9}C_3}{{}^{10}C_3 + {}^{9}C_3 + \ldots\ldots + {}^{3}C_3} = \frac{{}^{9}C_3}{{}^{11}C_4} = \frac{14}{55}$$

$\Rightarrow 69$

4. Sol.

$$\lim_{x\to 0} \frac{\ln(\sec(ex)) + \ln\left(\sec\left(e^2x\right)\right) + \ldots + \ln\left(\sec\left(e^{10}x\right)\right)}{e^{2\cos x}\frac{\left[e^{2-2\cos x}-1\right]}{(2-2\cos x)}\frac{(2-2\cos x)}{x^2}x^2}$$

$$= \frac{1}{e^2}\lim_{x\to 0} \frac{\ln(\sec ex) + \ln\left(\sec e^2x\right) + \ldots + \ln\left(\sec e^{10}x\right)}{x^2}$$

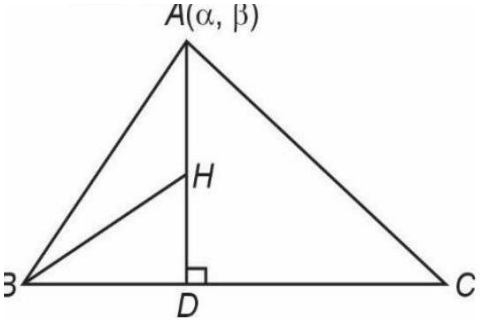
$$= \frac{1}{e^2}\lim_{x\to 0} \frac{e\tan ex + e^2\tan^2 x + \ldots\ldots + e^{10}\tan e^{10}x}{2x}$$

$$= \frac{1}{2e^2}\left[e^2 + e^4 + \ldots + e^{20}\right]$$

$$= \frac{1}{2}\frac{\left(e^{20}-1\right)}{e^2-1}$$

5. Answer (2)

Sol.



$AH:HD = 2:1$

$HD = \frac{4}{3}$

$m_{AC} = 2\sqrt{2} = \tan\theta$

$\Rightarrow \alpha = \frac{8}{3}\cos\theta, \beta = \frac{8}{3}\sin\theta$

$= \left(\frac{8}{9}, \frac{16\sqrt{2}}{9}\right)$

$\Rightarrow |\alpha + \sqrt{2}\beta| = \left[\left|\frac{40}{9}\right|\right] = 4$

Answer (4)

6. Answer (4)

Sol. $x = {}^9C_8 \cdot {}^8C_1 \cdot \frac{9!}{2!} = \frac{9\times8\times9!}{2} = 9\times4\times9!$

$$y = {}^9C_7 \cdot {}^7C_2 \cdot \frac{9!}{2!2!} = \frac{9\times7\times6\times9!}{2!} = 9\times21\times9!$$

$$\frac{y}{x} = \frac{21}{4} \Rightarrow 21x = 4y$$

7. Answer (2)

Sol. $g(f(x)) = 3\left(\frac{x}{2}\right)^2 - 8x + 18$

Notice that $g(x)$ is Quadratic, hence $f(x)$ has to be linear with leading coefficient $\frac{1}{2}$

$\Rightarrow f(x) = \frac{x}{2} + c$

$\because f(0) = -3 \Rightarrow f(x) = \frac{x-6}{2}$

Verify :

$g(f(x)) = 3\left(\frac{x-6}{2}\right)^2 + 2\left(\frac{x-6}{2}\right) - 3$

$= \frac{1}{4}\left[3x^2 - 36x + 108 + 4x - 24 - 12\right]$

$= \frac{1}{4}\left(3x^2 - 32x + 72\right)$

Now, $f(g(2)) = f(13) = \frac{7}{2}$

8. Answer (1)

Sol. $d_1 = 13 + d_2$

$$b_1 + 30d_2 = -277 \#(i)$$

$$b_1 + 42d_2 = -385 \#(ii)$$

Solving (i) and (ii)

$12d_2 = -108$

$\Rightarrow d_2 = -9$

$\therefore\ d_1 = 4$

$a_{78} = a_1 + 77d_1 = 327$

$\Rightarrow\ a_1 = 327 - 77(4)$

$= 327 - 308 = 19$

9. (4) $\frac{27}{2}$

Answer (2)

Sol. If $f\left(x^2+1\right) = x^4 + 5x^2 + 2$

Let $x^2 + 1 = t$

$$\Rightarrow\ f(t) = (t-1)^2 + 5(t-1) + 2$$
$$= t^2 - 2t + 1 + 5t - 3$$
$$= t^2 + 3t - 2$$
$$\Rightarrow \int_0^3 f(x)dx = \frac{x^3}{3} + \frac{3x^2}{2} - 2x\Big|_0^3$$
$$= \frac{27}{3} + \frac{27}{2} - 6 = 3 + \frac{27}{2} = \frac{33}{2}$$

10. Answer (1)

Sol. $|z - 6| = 5$

$\Rightarrow\ (x-6)^2 + y^2 = 25$

$|z + 2 - 6i| = 5$

$\Rightarrow\ (x+2)^2 + (y-6)^2 = 25$

Both circles are touching each other as $r_1 + r_2 = c_1c_2$

z = midpoint of c_1c_2 as radius is equal

$= \left(\frac{6-2}{2}, \frac{0+6}{2}\right) = (2,3)$

$z = 2 + 3i\ \Rightarrow z - 2 = 3i\ \Rightarrow z^2 + 4 - 4z = -9$

$\Rightarrow z^2 - 4z + 13 = 0$

$z^3 + 3z^2 - 15z + 141$

$= z\left(z^2 - 4z + 13\right) + 7z^2 - 28z + 141$

$= 7\left(z^2 - 4z + 13\right) + 50$

$= 50$

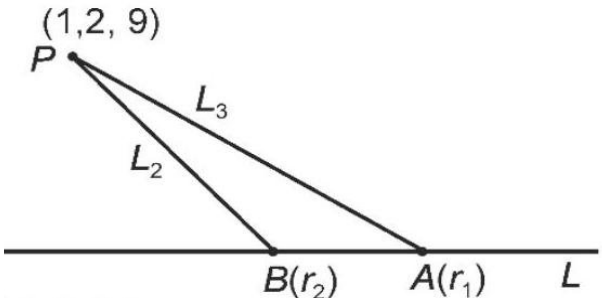
11. Answer (1)

Sol. Equation of line L_3 parallel to L_1 :

$\frac{x-1}{3} = \frac{y-2}{4} = \frac{z-a}{b} = k$

Equation of line L_3 parallel to L_2 :

$$\frac{x-1}{1}=\frac{y-2}{4}=\frac{z-a}{c}=I$$



Any point on line L:$(r+1,2r,r+1)$

$\overrightarrow{PA}$: $(r_1+1-1,2r_1-2,r_1+1-a)$

$\frac{r_1}{3}=\frac{2(r-1)}{4}=\frac{r_1+1-a}{b}$

$\Rightarrow\ r_1=3,b=4-a\overrightarrow{PB}$

is || to d.r. of L_2

$\frac{r_2}{1}=\frac{2(r_2-1)}{4}=\frac{r_1+1-a}{c}$

$\Rightarrow\ r_2=-1,a=c$

$\overrightarrow{PA}$:$3\hat{\square}+4\hat{\square}+(4-a)\hat{k}$

$\overrightarrow{PB}$: $-\hat{\square}-4\hat{\square}-a\hat{k}$ $\left.\begin{matrix}|\overrightarrow{PA}|^2=25+(4-a)^2\\|\overrightarrow{PB}|^2=17+a^2\end{matrix}\right\}$

equating, we get $a=3$,

$b=1,c=3$

12. Answer (1)

Sol. x^3+ax^2+bx+c

$=x\left(x^2+2\right)+a\left(x^2+2\right)-2x-2a+bx+c$

$=\left(x^2+2\right)(x+a)+x(b-2)+(c-2a)$

$\therefore b=2,c=2a$

$(a,c)\equiv(a,2a)\equiv(1,2),(2,4),\ldots(10,20)$

$\therefore$ total 10 elements

13. Answer (4)

Sol. $\because \frac{1}{\alpha}-\frac{1}{\beta}=\frac{1}{3}$

$$\therefore 9(\alpha-\beta)^2=\alpha^2\beta^2\#(1)$$

$\because \alpha+\beta=\frac{\lambda+3}{\lambda}$ and $\alpha\cdot\beta=\frac{3}{5}$

From eq. (1)

$9\left\{\left(\frac{\lambda+3}{\lambda}\right)^2-\frac{12}{\lambda}\right\}=\frac{9}{\lambda^2}$

$\therefore(\lambda+3)^2-12\lambda=1$

or $\lambda^2-6\lambda+8=0$

Sum of all values of $\lambda = 6$

14. Answer (3)

Sol. $\because \sum_{K=1}^{\infty} \frac{(-1)^{K+1}K(K+1)}{K!}$

$= \sum_{K=1}^{\infty} \frac{(-1)^{K+1}((K+1)+2)}{(K!)!}$

$= \sum_{K=1}^{\infty} \frac{(-1)^{K+1}}{(K-2)!} + \frac{2\cdot(-1)^{K+1}}{(K-1)!}$

$= \left(-1 + \frac{1}{1!} - \frac{1}{2!} + \frac{1}{3!} - \frac{1}{4!} + \ldots\right)$

$+ 2\left(1 - \frac{1}{1!} + \frac{1}{2!} - \frac{1}{3!} + \ldots\infty\right)$

$= -e^{-1} + 2e^{-1} = \frac{1}{e}$

15. Answer (4)

Sol. $\frac{\tan(A-B)}{\tan A} + \frac{\sin^2 C}{\sin^2 A} = 1$

$\Rightarrow \frac{\sin^2 C}{\sin^2 A} = \frac{1 - \tan(A-B)}{\tan A}$

$\Rightarrow \frac{\sin^2 C}{\sin^2 A} = \frac{1 - \sin(A-B)\cdot\cos A}{\cos(A-B)\sin A}$

$\Rightarrow \frac{\sin^2 C}{\sin^2 A} = \frac{\sin(B)}{\sin A \cdot \cos(A-B)}$

$\Rightarrow \sin^2 C = \frac{\sin A \cdot \sin B}{\cos A \cdot \cos B + \sin A \cdot \sin B}$

$\Rightarrow \frac{\tan^2 C}{1 + \tan^2 C} = \frac{\tan A \cdot \tan B}{1 + \tan A \cdot \tan B}$

$\Rightarrow \tan^2 C + \tan^2 C \cdot \tan A \cdot \tan B = \tan A \cdot \tan B + \tan^2 C \cdot \tan A \cdot \tan B$

$\Rightarrow \tan^2 C = \tan A \cdot \tan B \Rightarrow \tan A, \tan C, \tan B$

are in G.P

16. Answer (1)

Sol. Mean $= \frac{80+9+6}{10} = 9 \Rightarrow a + b = 100$

Also, Variance $= \left[(2-9)^2 + (3-9)^2 + (5-9)^2 + (10-9)^2 + (11-9)^2 + (13-9)^2 + (15-9)^2 + (21-9)^2 + (a-9)^2 + (b-a)^2\right]/10 = 34.2$

$\Rightarrow$ Solving for a and b,

we get $a = 3$ or 7

$$b = 7 \text{ or } 3$$

Deviation about median $= \frac{10+7}{2} = 8.5$

$$= \frac{\Sigma\left|x_i - 8.5\right|}{10} = 5$$

17. **Answer (3)**

Sol. $I = \int \frac{1-5\cos^2 x}{\sin^5 x\cos^2 x}dx$

$\int \frac{\sin^3 x\left(\sin^2 x - 4\cos^2 x\right)}{\left(\sin^4 x\cos x\right)^2}dx$

Let $t = \frac{1}{\sin^4 x\cos x}$

$dt = (-1)\left[\frac{-\sin^5 x - 4\sin^3 x\cos^2 x}{\left(\sin^4 x\cos x\right)^2}\right]$

$\Rightarrow I = \frac{1}{\left(\sin^4 x\cos x\right)} + C$

$f(x) = \frac{1}{\sin^4 x\cos x}$

$f\left(\frac{\pi}{6}\right) - f\left(\frac{\pi}{4}\right)$

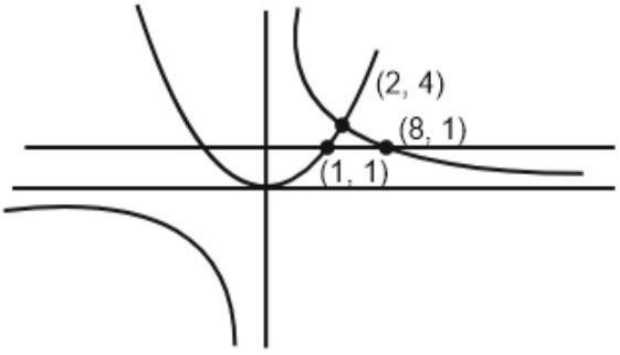
$\frac{1}{\left(\frac{1}{2}\right)^4\frac{\sqrt{3}}{2}} - \frac{1}{\left(\sqrt{\frac{1}{2}}\right)^5}$

$\frac{2^5}{\sqrt{3}} - (2)^{\frac{5}{2}}$

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

$= \frac{4}{\sqrt{3}}(8-\sqrt{b})$

18. Sol.



Area $= \int_1^2 \left(x^2-1\right)dx + \int_2^8 \left(\frac{8}{x}-1\right)dx$

$= \frac{x^3}{3} - x\Big]_1^2 + 8\ln x\Big]_2^8 - x\Big]_2^8$

$= \left(\frac{8}{3}-2\right) - \left(\frac{1}{3}-1\right) + 8[\ln 8 - \ln 2] - 6$

$= \frac{-14}{3} + 16\ln 2$

$= \frac{2}{3}[24\ln 2 - 7]$

19. Sol. $x\frac{dy}{dx} - \sin 2y = x^3\left(2 - x^3\right)\cos^2 y$

$\sec^2 y\frac{dy}{dx} - \frac{(2\tan y)}{x} = x^2\left(2 - x^3\right)$

Let $\tan y = t$

$\sec^2 y\frac{dy}{dx} = \frac{dt}{dx}$

$\frac{dt}{dx} - \frac{2t}{x} = x^2\left(2 - x^3\right)$

If $= e^{-\int\frac{2}{x}dx} = \frac{1}{x^2}$

$\frac{t}{x^2} = \int 2 - x^3 dx$

$\frac{\tan y}{x^2} = 2x - \frac{x^4}{4} + C$

$\tan y = 2x^3 - \frac{x^6}{4} + cx^2$

$\because y(2) = 0$

$0 = 16 - 16 + C(2) \Rightarrow C = 0$

$\tan y = 2x^3 - \frac{x^6}{4}$

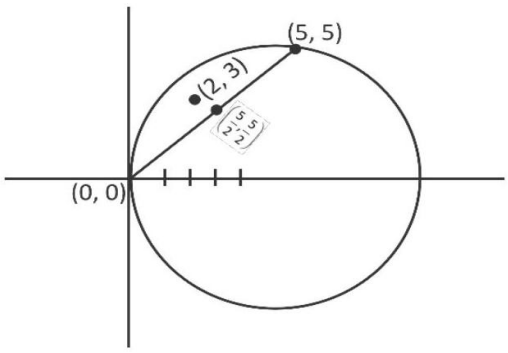
$\tan\left(y(1)\right) = 2 - \frac{1}{4}$

$= \frac{7}{4}$

20. Answer (4)

Sol. $x \geq 0$ and touching at $x(0,0)$

$C_1: (x-5)^2 + y^2 = 25$



$C_2 = (x-5)(x) + y(y-5) = 0$

Since the distance of chord is maximum from centre

$\left(\frac{5}{2}, \frac{5}{2}\right)$

$\Rightarrow (y-3) = (1)(x-2)$

$\Rightarrow (y-3) = (1)(x-2) = x - 2$

$\Rightarrow x - y + 1 = 0$

$a = -1$

$b = 1$

$a - b = -2$

SECTION - B

21. 22. The value of $\sum_{r=1}^{20}\left(\left|\sqrt{\pi\left(\int_0^r x|\sin\ \pi x|dx\right)}\right|\right)$ is ____

Answer (210)

Sol. $\sum_{r=1}^{20}\left|\sqrt{\left(\int_0^r x|\sin\ \pi x|dx\right)}\right|$

$$\int_0^1 x\sin\ \pi x dx = -\frac{x\cos\ \pi x}{\pi} + \int\ \frac{\cos\ \pi x}{\pi}$$

$$= -\frac{x\cos\ \pi x}{\pi} + \frac{\sin\ \pi x}{\pi^2}\Big]_0^1$$

$$= \frac{1}{\pi}$$

$$\Rightarrow \sum_{r=1}^{20}\ |\ \sqrt{\left(\int_0^r x|\sin\ \pi x|dx\right)}\ |$$

$$= \left|\sqrt{\int_0^1 \pi x|\sin\ \pi x|dx\ |} + \left|\sqrt{\int_0^2 \pi\int_0^2 x|\sin\ \pi x|dx\ |} + \cdots\right.\right.$$

$$\ldots + \left|\sqrt{\pi}\int_0^{20} x\right|\ \sin\ \pi x\ |\ dx$$

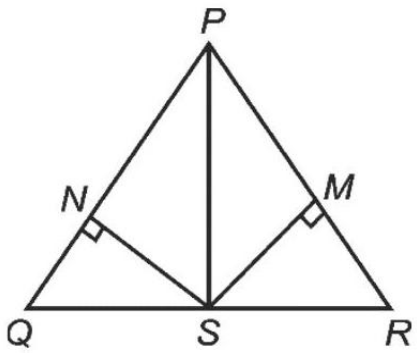
$$= \sqrt{1} + \sqrt{4} + \sqrt{9} + \cdots + \sqrt{400}$$

$$= 1 + 2 + 3 + \ldots + 20$$

$$= \frac{20\times 21}{2} = 210$$

22. Answer (37)

Sol.



$SM = SN$

$|\overrightarrow{PR}| = 9$

$a^2 + b^2 + 16 = 8$

$a^2 + b^2 = 65$

$\overrightarrow{PS} = \lambda\left(\frac{PQ}{|PQ|} + \frac{PR}{|PR|}\right)$

$\hat{i} - 7\hat{j} + 2\hat{k} = \lambda\left(\frac{-2\hat{i} - \hat{j} + 2\hat{k}}{3} + \frac{a\hat{i} + b\hat{j} - 4\hat{k}}{9}\right)$

$\Rightarrow \hat{i} - 7\hat{j} + 2\hat{k} = \frac{\lambda}{9}[(a-6)\hat{i} + (b-3)\hat{j} + 2\hat{k}] \Rightarrow \lambda = 9$

from k component.

Now comparing i and j component

$a - 6 = 1 \Rightarrow a = 7$

$b - 3 = -7 \Rightarrow b = -4$

$\Rightarrow 3a - 4b = 21 + 16$

$= 37$

24. Answer (8)

Sol. $H : \frac{x^2}{8} - \frac{y^2}{8\cos^2\theta} = 1$

$$e_1^2 = 1 + \frac{8\cos^2\theta}{8} = 1 + \cos^2\theta$$

$$I_1 = \frac{2 \cdot 8\cos^2\theta}{2\sqrt{2}} = 4\sqrt{2}\cos^2\theta$$

$$E: \frac{x^2}{6\cos^2\theta} + \frac{y^2}{6} = 1$$

$$e_2^2 = 1 - \frac{6\cos^2\theta}{6} = \sin^2\theta$$

$$I_2 = \frac{2 \cdot 6\cos^2\theta}{\sqrt{6}} = 2\sqrt{6}\cos^2\theta$$

$$e_1^2 = e_2^2\left(1 + \sec^2\theta\right)$$

$$\Rightarrow \left(1 + \cos^2\theta\right) = \sin^2\theta\left(\frac{1 + \cos^2\theta}{\cos^2\theta}\right)$$

$$\Rightarrow \tan^2\theta = 1 \Rightarrow \theta = \frac{\pi}{4}$$

$$\frac{I_1 \cdot I_2}{e_1 e_2} = \frac{4\sqrt{2}\cos^2\theta \cdot 2\sqrt{6}\cos^2\theta}{\sqrt{1 + \cos^2\theta} \cdot \sin\theta}$$

$$= \frac{4 \cdot \sqrt{2} \cdot \frac{1}{2} \cdot 2\sqrt{6} \cdot \frac{1}{2}}{\frac{\sqrt{3}}{2} \cdot \frac{1}{\sqrt{2}}} = \frac{4\sqrt{3}}{\sqrt{3}} \times 2 = 8$$

25. Answer (90)

Sol. Let first three terms be $\frac{a}{r}, a, ar$

$\frac{a}{r} \cdot a \cdot ar = 27$

$a^3 = 27$

$a = 3$

Now $S = \frac{a}{r} + a + ar$

$\Rightarrow S = \frac{3}{r} + 3 + 3r$

If $r > 0 \Rightarrow r + \frac{1}{r} \geq 2$

$r < 0 \Rightarrow r + \frac{1}{r} \leq -2$

Case I:

If $r > 0$

$S = 3\left[r + \frac{1}{r} + 1\right]$

$s \geq 9$

Case II

If $r < 0$

$S = 3\left(r + \frac{1}{r} + 1\right)$

$S \leq -3$

$S \in (-\infty, -3] \cup [9, \infty)$

$S \in R - (-3, 9)$

$a = -3\ b = 9$

$a^2 + b^2 = 90$

PHYSICS

SECTION – A

26. Sol. $-20^\circ C$ to $0^\circ q = mS_{ice}\ \Delta T$ at $0^\circ C$ phase change take place. $0^\circ C$ to $100^\circ C, q = ms_\omega \Delta T$ at $100^\circ C$ phase change take place.

27. Answer (2)

Sol. B at location of mid wire

$$= \frac{\mu_0 3}{2\pi 3 \times 10^{-2}} + \frac{\mu_0 \times 2}{2\pi \times 2 \times 10^{-2}}$$
$$= 10^{-7}\left(2 \times 10^2 + 2 \times 10^2\right) = 4 \times 10^{-5}$$
$$F = 4 \times 10^{-5} \times 1 \times 15 \times 10^{-2}$$
$$= 60 \times 10^{-7}$$
$$= 6 \times 10^{-6}\ \text{N}$$

28. Answer (3)

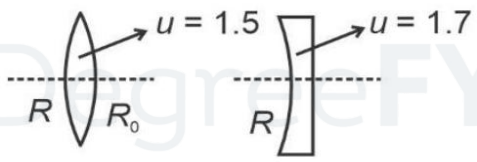
Sol. $i = i_0 \frac{t}{T}$

$$i_{rms}^2 = \frac{\int_0^T \frac{i_0^2 t^2 dt}{T^2}}{\int_0^T dt} = \frac{i_0^2 \frac{T}{3}}{T}$$

$$i_{rms} = \frac{i_0}{\sqrt{3}}$$

29. Answer (4)

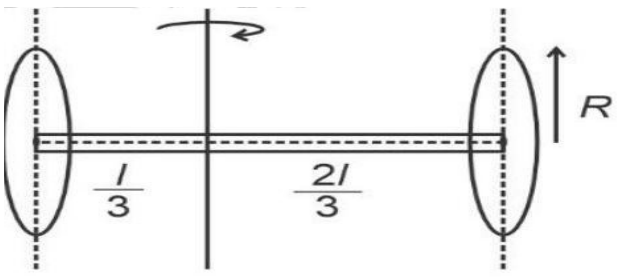
Sol.



$$f_1 = |f_2|$$
$$(1.5 - 1)\left(\frac{1}{R} - \frac{1}{-R_0}\right) = \left|(1.7 - 1)\left(\frac{1}{-R_0} - \frac{1}{\infty}\right)\right|$$
$$\frac{1}{2R} + \frac{1}{2R_0} = \frac{7}{10R_0}$$
$$\frac{1}{2R} = \frac{1}{5R_0}$$
$$\frac{R}{R_0} = \frac{5}{2}$$

30. Answer (1)

Sol.



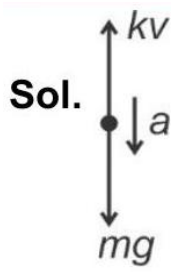
$$I = \frac{mR^2}{4} + \frac{ml^2}{9} + \frac{mR^2}{4} + \frac{m \cdot 4l^2}{9} + \frac{ml^2}{12} + \frac{ml^2}{36}$$

$$I = \frac{mR^2}{2} + \frac{2ml^2}{3}$$

$$I = 3.9 \times 10^{-2} \text{kgm}^2$$

$$\alpha = \frac{\tau}{l} = \frac{0.43}{3.9 \times 10^{-2}} = 11$$

31. Answer (2)



$$a = g - \frac{k}{m}v$$

$$\int_{v=0}^{v} \frac{dv}{g - \frac{k}{m}v} = \int_{t=0}^{t} dt$$

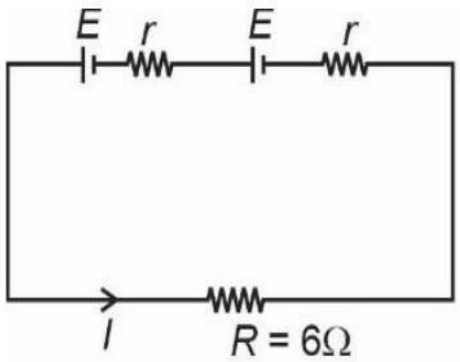
$$\ln\left(\frac{g - \frac{k}{m}v}{g}\right) = -\frac{k}{m}t$$

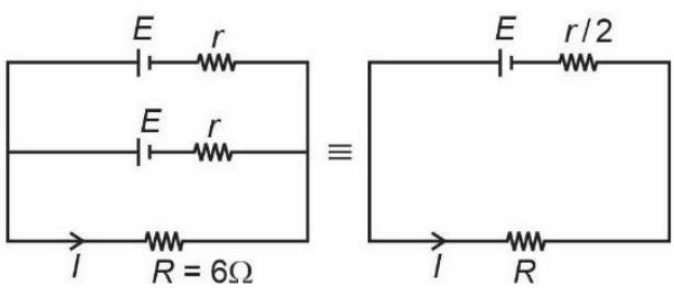
$$g - \frac{k}{m}v = ge^{-\frac{k}{m}t}$$

$$v = \frac{m}{k}g\left(1 - e^{-\frac{k}{m}t}\right)$$

32. Answer (1)

Sol.



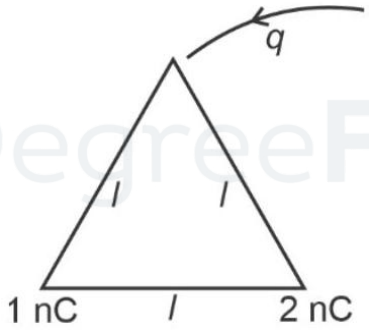


$$\frac{2E}{2r+6}=\frac{E}{\frac{r}{2}+6}$$

$$r=6\Omega$$

33. Answer (4)

Sol.



$$\begin{aligned} w &= \Delta U \\ &= \frac{k}{l}\left(1\times10^{-9}\times3\times10^{-9}+2\times10^{-9}\times3\times10^{-9}\right) \\ &= \frac{9\times10^{9}}{3\times10^{-2}}\cdot9\times10^{-18} \\ &= 27\times10^{-7} \\ &= 2.7\mu\,\text{J} \end{aligned}$$

34. Answer (4)

Sol. Small pinhole acts like a point source due to diffraction.

Slit width ↑ diffraction ↓

35. Answer (2)

Sol. $B_x=\frac{\mu_0 iR^2}{2\left(R^2+x^2\right)^{\frac{3}{2}}}=\frac{\mu_0 IR^2}{2\left(R^2+3R^2\right)^{\frac{3}{2}}}=\frac{\mu_0 R}{16R}$

$$B_0 = \frac{\mu_0 I}{2R}$$

$$B_x = \frac{B_0}{8} = 2\mu \top$$

36. Answer (2)

Sol. $V = \frac{ER}{R+r}$

$$l\alpha \frac{R}{r+R}$$

$$\frac{120}{180} = \frac{4(12+r)}{12(4+r)}$$

$$r = 4\Omega$$

37. Answer (4)

Sol. Number of nucleons initially $= 8$

Number of nucleons finally $= 8 + 10 + 9 = 27$

$$R = R_0(A)^{\frac{1}{3}}$$

$$\text{Area}_1 = 4\pi R_0^2(8)^{\frac{2}{3}} = 4k$$

$$\text{Area}_2 = 4\pi R_0^2(27)^{\frac{2}{3}} = 9k$$

$$\%\ \text{change} = \frac{9-4}{4} \times 100 = 225\%$$

38. Answer (2)

Sol. Zero error $= 4LC = 0.4$ mm

$$\begin{aligned} \text{Length} &= 15\text{MSD} + 5LC - 0.4 \text{ mm} \\ &= 15\text{MSD} + 0.1 \text{ mm} \\ &= 15.1 \text{ mm} \end{aligned}$$

39. Answer (4)

Sol.

$$f_{\max} = \frac{\sqrt{3}}{2} \cdot 50 \cdot \frac{\sqrt{3}}{2} = 50 \times \frac{3}{4}$$

$$F + 50 \cdot \frac{1}{2} = 50 \cdot \frac{3}{4}$$

$$F = \frac{50}{4} = 12.5 \text{ N}$$

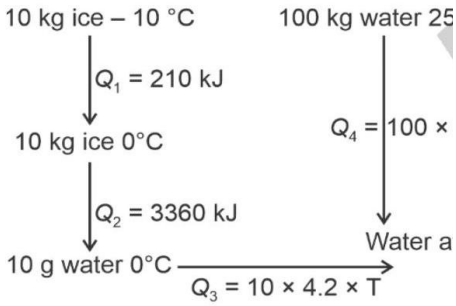
40. Answer (3)

Sol. $\Delta I = \frac{FI}{AY}$

$$\frac{I_1}{A_1 Y_1} = \frac{I_2}{A_2 Y_2}$$
$$\frac{Y_1}{Y_2} = \frac{I_1}{I_2} \cdot \frac{A_2}{A_1}$$
$$= \frac{6}{5.4} \times \frac{4.5}{3}$$
$$= \frac{5}{3}$$

41. **Answer (1)**

Sol.



$Q_1 + Q_2 + Q_3 = Q_4$
$\Rightarrow 210 + 3360 + 42\,T = 420(25 - T)$
$T = 15^\circ C$

42. Answer (2)

Sol.

$$I = \frac{12 - 0.7}{0.3} = 37.6\ \text{mA}$$

Current through $\Phi_1 = \frac{37.6}{2}$
$= 18.8\ \text{mA}$

43. Answer (2)

Sol. Let time between two consecutive drops to

$$\frac{1}{2}g(5t_0)^2 = H = \text{ height of tap}$$

$$H = \frac{25}{2}gt_0^2$$

$$t_0 = \frac{1}{5}$$

Distance of fourth drop from tap

$$= \frac{1}{2}g(2t_0)^2$$
$$= \frac{4}{5}$$
$$= 0.8$$

$$\text{Height} = 5 - 0.8$$
$$= 4.2 \text{ m}$$

44. Answer (3)

Sol. Speed of EMw in medium $(v) = \frac{2\times10^{15}}{10^7}$

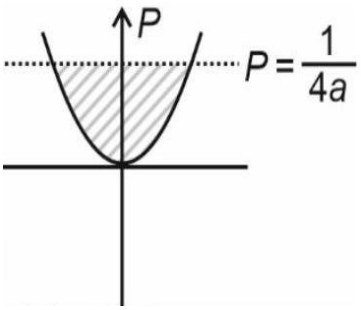
$$= 2 \times 10^8$$

$$\mu = \frac{c}{v}$$
$$= 1.5$$

45. Answer (1)

Sol. Work done = Area

$\because$ area can be easily calculated by shifting the vertex of parabola at origin.



$$\text{Area} = \int_{-1}^{1}\left(\frac{1}{4a} - \frac{v^2}{4a}\right)dv$$
$$= -\frac{1}{3a}$$

SECTION - B

46. Answer (3)

Sol. $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

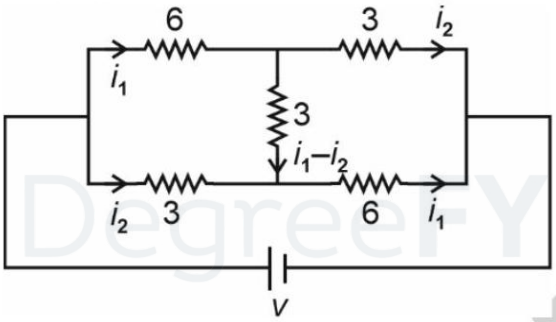
$\frac{1}{18} = (1.5 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f_w} = \left(\frac{1.5}{\frac{4}{3}} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$f_w = 18 \times 4 = 72 \text{ cm}$

47. Answer (21)

Sol.



$$-6i_1 - 3(i_1 - i_2) + 3i_2 = 0$$

$$-3i_2 - 6i_1 + v = 0$$

$$R = \frac{v}{i_1 + i_2} = \frac{v}{\frac{5v}{21}} = \frac{21}{5}$$

48. 48. Answer (2)

Sol. $x = A\sin(\omega t)$

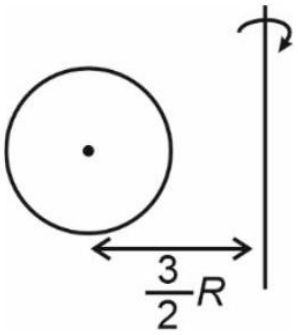
Potential energy is maximum at extreme position.

$$t = \frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}, \ldots$$

$$\beta = 2$$

49. Answer (265)

Sol.



$$I = \frac{2}{5}mR^2 + m \cdot \frac{9}{4}R^2$$
$$I = \frac{53}{20}mR^2$$
$$k = \sqrt{\frac{53}{20}} \times 10 \text{ cm}$$
$$= \sqrt{265} \text{ cm}$$

50. Answer (2)

Sol. $\lambda = \frac{h}{\sqrt{2mKE}}$

$$\frac{\lambda_D}{\lambda\alpha} = \frac{\sqrt{2E \times 4}}{\sqrt{E \times 2}} = 2$$

CHEMISTRY

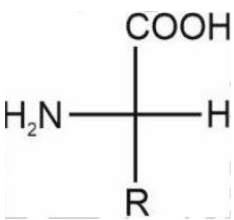
SECTION - A

51. Answer (4)

Sol. A, C and E are correct.

Answer (2)

Sol. The general form of α-amino acid:



$R \Rightarrow HO - CH_2 - \Rightarrow$ Serine (Ser)
$R \Rightarrow CH_3 - CHOH - \Rightarrow$ Threonine (Thr) (essential amino acid)
$R \Rightarrow HOOC - CH_2 - \Rightarrow$ Aspartic acid (Asp)
$R \Rightarrow CH_3 - \Rightarrow$ Alanine (Ala)
$R \Rightarrow H - \Rightarrow$ Glycine (Gly)

53. Answer (4)

Sol. Radius decreases down the group
Highest - K
Lowest - Br

54. Answer (4)

Sol. Reaction 4 is Hoffmann Bromamide degradation.

55. Answer (4)

Sol. Statement-I is correct
Statement II is correct
56. Answer (2)
Sol. A is correct
C is correct
E is correct
57. Answer (1)
Sol. $\Delta E = 0, \Delta H = 0$

$$w = -2.303 \times PV \log \frac{5}{2}$$
$$= -2.303 \times 0.5 \times 10^6 \times 20 \times 10^{-3}[0.3979]$$

$\Rightarrow -9.1$ kJ
q = +9.1 kJ

58. Answer (3)

Sol. Statement-I is incorrect as only SF_4 have unequal bond length.
Statement-II is incorrect as O_2^+ have highest bond order.

59. Answer (3)

Sol. $\frac{t_{1/8}}{t_{1/10}} = \frac{\log 8}{\log 10} = 0.9 \Rightarrow \frac{t_{1/8}}{t_{1/10}} \times 10 = 9$

60. Answer (4)

Sol. $X = C_3H_6Cl_2$

$$Y = CH_3 - C \equiv CH$$

Z

O

Q =

I

I

61. Sol. $x + y = 100$

$$HCl + BOH \rightarrow BCl$$
$$x$$
$$0$$
$$pH = 9, pOH = 5$$
$$5 = 5.699 + \log_2 O$$
$$-0.699 = \log \frac{\text{Salt}}{\text{Base}}$$
$$\Rightarrow \frac{\text{Salt}}{\text{Base}} = \frac{1}{5}$$
$$\Rightarrow \frac{x}{y - x} = \frac{1}{5}$$
$$5x = y - x$$
$$6x = y$$
$$\Rightarrow x = 14.3, y = 85.7$$

62. Answer (3)

Sol. x = phenol
y = salicylic acid
Compound y is more acidic.

63. Answer (4)

Sol. $[Ni(CN)_4]^{2-}$ = diamagnetic
$[Ni(CO)_4]$ = diamagnetic
$[Ni(Cl)_4]^{2-}$ = paramagnetic

64. Answer (4)

Sol. A. Bromobenzene
B. Ortho-nitro bromobenzene
C. Para-nitro bromobenzene

Both B and C can be separated using fractional distillation.

65. Answer (3)

Sol. $x_A = \frac{2}{5}; x_B = \frac{3}{5}$

$$320 = P^\circ_A\left(\frac{2}{5}\right) + P^\circ_B\left(\frac{3}{5}\right)$$
$$1600 = 2P^\circ_A + 3P^\circ_B \Rightarrow 4800 = 6P^\circ_A + 9P^\circ_B$$

New solution;

$$n_A = 3$$
$$n_B = 4$$
$$x_A = \frac{3}{7}; x_B = \frac{4}{7}$$
$$328.6 = P^\circ_A\left(\frac{3}{7}\right) + P^\circ_B\left(\frac{4}{7}\right)$$
$$2300.2 = 3P^\circ_A + 4P^\circ_B$$

$\Downarrow$

$$4600.4 = 6P^\circ_A + 8P^\circ_B$$

$\Rightarrow P^\circ_B = 199.6 \approx 200$
$P^\circ_A = 500.6 \approx 500$

66. Answer (2)

Sol. A is correct
B is correct
C is correct

BP	NH_3	PH_3	AsH_3	SbH_3	BiH_3
(K)	238	185	210	254	290

D is incorrect

67. Answer (1)

Sol. Order of stability

$$CH \equiv C^- > CH_2 = CH^- > CH_3 - CH_2^-$$

68. Answer (3)
Sol. $\Psi = 0$ for node
69. Answer (4)
Sol. Sc^{3+}, Zn^{2+} and Ti^{4+} are colourless
Statement I is Incorrect
Statement II is Incorrect

70. Answer (3)

Sol. First line

$$(3 \rightarrow 2)\frac{1}{\lambda} = R \times 1 \times \left[\frac{1}{4} - \frac{1}{9}\right]$$
$$= \frac{5R}{36}$$

Second line

$$(4 \rightarrow 2)\ \frac{1}{\lambda} = R \times 1 \times \left[\frac{1}{4} - \frac{1}{16}\right]$$
$$= \frac{3R}{16}$$

Third line

$$(5 \rightarrow 2)\ \frac{1}{\lambda} = R \times 1 \times \left[\frac{1}{4} - \frac{1}{25}\right]$$
$$= \frac{21R}{100}$$

SECTION - B

Answer (3)

71. Sol. m.eq. of $KMnO_4 = 300$ (Limiting reagent)
m.eq. of $KI = 600$

$$\Rightarrow 300 = n_{I_2} \times 2$$
$$n_{I_2} = 150 \text{ m.moles}$$
$$n_{Hypo} = 300 \text{ m.moles}$$
$$300 = 0.1 \times V$$
$$V = 3000 \text{ mL}$$
$$= 3 \text{ L}$$

72. Answer (4)

Sol. The compound is $C_xH_yBr_z$

$$\%Br = \frac{0.75 \times 80}{188 \times 0.53} \times 100\% \approx 60.2\%$$
$$\%C = \frac{1.32 \times 12}{44 \times 1} \times 100\% = 36\%$$
$$\%H = 100 - (60 + 36)\%$$
$$=\approx 4\%$$

73. Answer (3)

Sol. $HA \rightleftharpoons H^+(aq) + A^-(aq)$

$$pKa(Ha) = 4$$
$$\therefore Ka = 10^{-4}$$
$$[H^+] = \sqrt{C \cdot Ka}$$
$$= \sqrt{10^{-2} \times 10^{-4}}$$
$$[H^+] = \sqrt{10^{-6}} = 10^{-3}$$
$$\therefore pH = 3$$

74. Answer (24)

Sol. Δ (oxidation number) for Reduction = 6

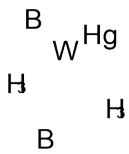
Δ (oxidation number) for oxidation $= 2 \times 4 = 8$

n = LCM(6,8)

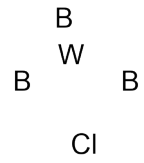
= 24

75. Answer (6)

Sol. - $[Pt(NH_3)(H_2O)BrCl] \Rightarrow [Mabcd]$







$\Rightarrow$ 3 geometrical isomers.
X = 3

- $[CrCl_2(ox)_2]^{3-} \Rightarrow [M(AA)_2a_2]^{\pm n}$



$\Rightarrow$ Optically inactive

Y = 1

- $[Co(NH_3)_3(NO_2)_3] \Rightarrow [Ma_3b_3]$



fac
Z = 2
X + Y + Z = 6



mer

DegreeFYD