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in RMO 2025



Aarav Gupta
Gold Medalist

66th International
Mathematical Olympiad
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Yug Gandhi
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Singapore Math
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Arjun Tyagi
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International Olympiad
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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. Let $[\cdot]$ denote the greatest integer function. If the domain of the function

$f(x) = \cos^{-1}\left(\frac{4x+2[x]}{3}\right)$ is $[\alpha, \beta]$, then $12(\alpha + \beta)$ is equal to

- (1) 6
- (2) 8
- (3) 9
- (4) 4

Answer (1)

Sol. $f(x) = \cos^{-1}\left(\frac{4x+2[x]}{3}\right)$

$$-1 \leq \frac{4x+2[x]}{3} \leq 1$$

$$-3 \leq 4x+2[x] \leq 3$$

Case 1: $x \in [0, 1)$

$$[x] = 0$$

$$-3 \leq 4x \leq 3$$

$$\Rightarrow -\frac{3}{4} \leq x \leq \frac{3}{4}$$

$$\Rightarrow x \in \left[0, \frac{3}{4}\right)$$

Case 2: $x \in [-1, 0)$

$$[x] = -1$$

$$-3 \leq 4x - 2 \leq 3$$

$$-\frac{1}{4} \leq x \leq \frac{5}{4}$$

$$\Rightarrow x \in \left[-\frac{1}{4}, 0\right)$$

Case 3: $x \in [1, 2)$

$$[x] = 1$$

$$-3 \leq 4x + 2 \leq 3$$

$$-\frac{5}{4} \leq x \leq \frac{1}{4}$$

No solution

Case 4: $x \in [-2, -1)$

$$[x] = -2$$

$$-3 \leq 4x - 4 \leq 3$$

$$\frac{1}{4} \leq x \leq \frac{7}{4} \text{ (No solution)}$$

$$\therefore \text{Domain is } \left[-\frac{1}{4}, \frac{3}{4}\right)$$

$$\therefore 12(\alpha + \beta) = 6$$

2. If the set of all solutions of $|x^2 + x - 9| = |x| + |x^2 - 9|$ is $[\alpha, \beta] \cup [\gamma, \infty)$, then $(\alpha^2 + \beta^2 + \gamma^2)$ is equal to:

- (1) 9
- (2) 18
- (3) 36
- (4) 72

Answer (2)

Sol. $|x^2 + x - 9| = |x| + |x^2 - 9|$

The property $|A + B| = |A| + |B|$ if $A \cdot B \geq 0$

$$A = x$$

$$B = x^2 - 9$$

$$A + B = x^2 + x - 9$$

$$\therefore x(x^2 - 9) \geq 0$$

$$x(x+3)(x-3) \geq 0$$

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8. The number of ways, of forming a queue of 4 boys and 3 girls such that all the girls are not together, is:
- (1) 5040 (2) 3050
(3) 3410 (4) 4320

Answer (4)

Sol. \Rightarrow Total ways = 7!

We need to remove cases where all 3 girls are together.

$$\Rightarrow \boxed{G_1 G_2 G_3} B_1 B_2 B_3 B_4$$

$$\Rightarrow 3! \times 5!$$

$$\Rightarrow \text{Required ways} = 7! - 3! \times 5! = 4320$$

9. Let the smallest value of $k \in \mathbb{N}$, for which the coefficient of x^3 in $(1+x)^3 + (1+x)^4 + (1+x)^5 + \dots + (1+x)^{99} + (1+kx)^{100}$, $x \neq 0$ is $\left(43n + \frac{101}{4}\right) \cdot {}^{100}C_3$

for some $n \in \mathbb{N}$, be p . Then the value of $p + n$ is:

- (1) 10 (2) 11
(3) 12 (4) 13

Answer (2)

Sol. The coefficient of x^3 in $(1+x)^3 + (1+x)^4 + \dots + (1+kx)^{100} = {}^3C_3 + {}^4C_3 + \dots + {}^{99}C_3 + k^3 \cdot {}^{100}C_3$

$$= {}^{100}C_4 + k^3 \cdot {}^{100}C_3$$

$$\therefore {}^{100}C_4 + k^3 \cdot {}^{100}C_3 = \left(43n + \frac{101}{4}\right) \cdot {}^{100}C_3$$

$$\text{Or, } \frac{97}{4} + k^3 = 43n + \frac{101}{4}$$

$\therefore k^3 = 43n + 1$
Here $43n + 1$ must be a perfect cube.

$$\therefore n = 5 \text{ and } k = 6$$

$$\therefore n + p = 11$$

10. Suppose that the mean and median of the non-negative numbers 21, 8, 17, a , 51, 103, b , 13, 67, ($a > b$), are 40 and 21, respectively. If the mean deviation about the median is 26, then $2a$ is equal to:
- (1) 109 (2) 117
(3) 161 (4) 131

Answer (4)

Sol. Mean = 40 = $\frac{21 + 8 + 17 + a + 51 + 103 + b + 13 + 67}{9}$

$$\Rightarrow \boxed{a + b = 80} \quad \dots(1)$$

With 9 terms median will be 5th term

8, 13, 17, 21, 51, 67, 103

Given median is 21

$$\therefore b \leq 21$$

$$\therefore \text{Sequence : } 8, 13, 17, b, 21, a, 51, 67, 103$$

$$\text{MD about median} = \frac{\sum |x_i - M|}{N} = 26$$

$$\Rightarrow \sum |x_i - M| = 234$$

$$13 + 8 + 4 \cdot 0 + 30 + 46 + 82 + |a - 21| + |b - 21| = 234$$

$$\Rightarrow |a - 21| + |b + 21| = 51$$

$$\therefore a > 21 \text{ and } b < 21$$

$$\Rightarrow \boxed{a - b = 51}$$

From (1) and (2)

$$2a = 131$$

11. Let the line $L_1 : x + 3 = 0$ intersect the lines $L_2 : x - y = 0$ and $L_3 : 3x + y = 0$ at the points A and B , respectively. Let the bisector of the obtuse angle between the lines L_2 and L_3 intersect the line L_1 at the point C . Then $BC^2 : AC^2$ is equal to:

- (1) 5 : 1 (2) 1 : 5
(3) 2 : 3 (4) 3 : 2

Answer (1)

Sol. $L_1 : x + 3 = 0$

$$L_2 : x - y = 0$$

$$L_3 : 3x + y = 0$$

$$\Rightarrow A(-3, 3) B(-3, 9)$$

Obtuse angle bisector of L_3 and L_2

$$\frac{x - y}{\sqrt{2}} = \frac{3x + y}{\sqrt{10}}$$

$$\Rightarrow c \left(-3, \frac{9 - 3\sqrt{5}}{1 + \sqrt{5}} \right)$$

$$\text{Now, } \frac{(BC)^2}{(AC)^2} = \left(\frac{9 - \frac{9 - 3\sqrt{5}}{1 + \sqrt{5}}}{3 - \frac{9 - 3\sqrt{5}}{1 + \sqrt{5}}} \right)^2 = 5$$

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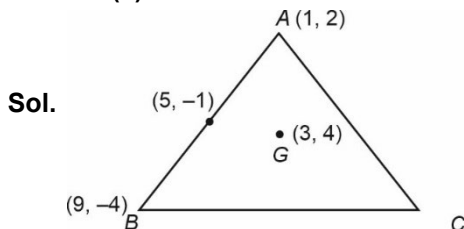
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12. Let the vertex A of a triangle ABC be $(1, 2)$, and the mid-point of the side AB be $(5, -1)$. If the centroid of this triangle is $(3, 4)$ and its circumcenter is (α, β) , then $21(\alpha + \beta)$ is equal to:

- (1) 309 (2) 403
(3) 497 (4) 524

Answer (3)



Sol.

Vertex B will be $(9, -4)$

Vertex C will be $(-1, 14)$

$$(\alpha - 9)^2 + (\beta + 4)^2 = (\alpha - 1)^2 + (\beta - 2)^2 = (\alpha + 1)^2 + (\beta - 14)^2$$

$$(\alpha - 1)^2 + (\beta - 2)^2 = (\alpha - 9)^2 + (\beta + 4)^2$$

$$\Rightarrow 4\alpha - 3\beta = 23 \quad \dots(1)$$

$$(\alpha - 1)^2 + (\beta - 2)^2 = (\alpha + 1)^2 + (\beta - 14)^2$$

$$\Rightarrow -\alpha + 6\beta = 48 \quad \dots(2)$$

By (1) and (2)

$$\beta = \frac{215}{21} \text{ and } \alpha = \frac{94}{7}$$

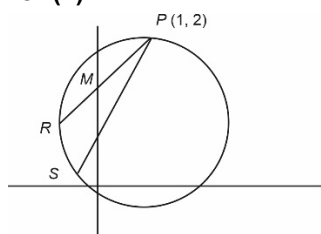
$$\therefore 21(\alpha + \beta) = 215 + 94 \times 3 = 497$$

13. Suppose that two chords, drawn from the point $(1, 2)$ on the circle $x^2 + y^2 + x - 3y = 0$ are bisected by the y -axis. If the other ends of these chords are R and S , and the mid point of the line segment RS is (α, β) , then $6(\alpha + \beta)$ is equal to

- (1) 1 (2) 3
(3) 4 (4) 6

Answer (2)

Sol.



Let $M(0, K)$

$R(x_R, y_R)$

$$\frac{x_R + 1}{2} = 0 \Rightarrow x_R = -1$$

$$\frac{y_R + 2}{2} = K \Rightarrow y_R = 2K - 2$$

Now R lies on circle

$$x^2 + y^2 + x - 3y = 0$$

$$1 + (2K - 2)^2 - 1 - 3(2K - 2) = 0$$

$$(2K - 2)(2K - 2 - 3) = 0$$

$$\Rightarrow K = \frac{5}{2} \text{ or } 1$$

$$\therefore R(-1, 3) \text{ S}(-1, 0)$$

$$\therefore (\alpha, \beta) = \left(-1, \frac{3}{2}\right)$$

$$6(\alpha + \beta) = -6 + 9 = 3$$

14. A line with direction ratios, $1, -1, 2$ intersects the lines $\frac{x}{2} = \frac{y}{3} = \frac{z+1}{3}$ and $\frac{x+1}{-1} = \frac{y-2}{1} = \frac{z}{4}$ at the points P and Q , respectively. If the length of the line segment PQ is a , then $225\alpha^2$ is equal to:

- (1) 1024 (2) 1014
(3) 1104 (4) 1204

Answer (2)

Sol. $P(2\lambda, 3\lambda, 3\lambda - 1)$

$$Q(-k - 1, k + 2, 4k)$$

$$\frac{2\lambda + k + 1}{1} = \frac{3\lambda - k - 2}{-1} = \frac{3\lambda - 1 - 4k}{2}$$

Solving equation (i) and (ii)

$$\lambda = \frac{1}{5}, k = \frac{-8}{15}$$

$$\therefore P\left(\frac{2}{5}, \frac{3}{5}, \frac{-2}{5}\right) \quad Q\left(\frac{-7}{15}, \frac{22}{15}, \frac{-32}{15}\right)$$

$$\alpha^2 = (PQ)^2 = \left(\frac{13}{15}\right)^2 + \left(\frac{-13}{15}\right)^2 + \left(\frac{26}{15}\right)^2$$

$$= \frac{169}{225}(1+1+4) = \frac{6 \times 169}{225}$$

$$225\alpha^2 = 1014$$

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15. The square of the distance of the point $(-2, -8, 6)$ from the line $\frac{x-1}{1} = \frac{y-1}{2} = \frac{z}{-1}$ along the line

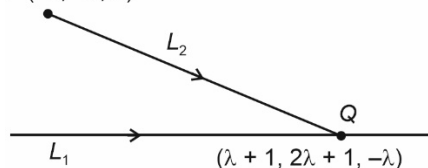
$$\frac{x+5}{1} = \frac{y+5}{-1} = \frac{z}{2} \text{ is equal to:}$$

- (1) 3 (2) 6
(3) 8 (4) 12

Answer (2)

Sol. $\overline{PQ} \parallel (1, -1, 2)$

$P(-2, -8, 6)$



$$\frac{\lambda + 3}{1} = \frac{2\lambda + 9}{-1} = \frac{-\lambda - 6}{2}$$

Solving : $\lambda = -4$

$\therefore Q(-3, -7, 4)$

$$(PQ)^2 = 1 + 1 + 4 = 6$$

16. If

$$y = \tan^{-1}\left(\frac{3 \cos x - 4 \sin x}{4 \cos x + 3 \sin x}\right) + 2 \tan^{-1}\left(\frac{x}{1 + \sqrt{1 - x^2}}\right),$$

then $\frac{dy}{dx}$ at $x = \frac{\sqrt{3}}{2}$ is equal to

- (1) 3 (2) -1
(3) 1 (4) 2

Answer (3)

Sol. $y = \tan^{-1}\left(\frac{3 \cos x - 4 \sin x}{4 \cos x + 3 \sin x}\right) + 2 \tan^{-1}\left(\frac{x}{1 + \sqrt{1 - x^2}}\right)$

$$= \tan^{-1}\left(\frac{\frac{3}{4} - \tan x}{1 + \frac{3}{4} \tan x}\right) + 2 \tan^{-1}\left(\frac{\sin \theta}{1 + \cos \theta}\right)$$

(let $x = \sin \theta$)

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

$$= \tan^{-1}\left(\frac{3}{4}\right) - x + \theta$$

$$= \tan^{-1}\left(\frac{3}{4}\right) - x + \sin^{-1} x$$

$$\frac{dy}{dx} = -1 + \frac{1}{\sqrt{1 - x^2}}$$

$$x = \frac{\sqrt{3}}{2}$$

$$\frac{dy}{dx} = -1 + 2 = 1$$

17. Let f be a real polynomial of degree n such that $f(x) = f'(x)f''(x)$, for all $x \in R$. If $f(0) = 0$, then

$$36 \left(f'(2) + f''(2) + \int_0^2 f(x) dx \right) \text{ is equal to}$$

- (1) 42 (2) 46
(3) 56 (4) 66

Answer (3)

Sol. $n = (n-1) + (n-2)$

$$\Rightarrow n = 3$$

$$f(0) = 0 \Rightarrow d = 0$$

$$ax^3 + bx^2 + cx = (3ax^2 + 2bx + c)(6ax + 2b)$$

$$= 18a^2x^3 + 18abx^2 + x(6ac + 4b^2) + 2bc$$

$$a = 18a^2 \Rightarrow a = \frac{1}{18}$$

$$bc = 0 \Rightarrow b = 0 \text{ or } c = 0$$

$$c = 6ac + 4b^2$$

$$\text{If } b = 0, c = 6ac \Rightarrow c = 0$$

$$\text{If } c = 0, 4b^2 = 0 \Rightarrow b = 0$$

$$\therefore b = c = d = 0$$

$$f(x) = \frac{x^3}{18}$$

$$f'(2) = \frac{2}{3}$$

$$f''(2) = \frac{2}{3}$$

$$\int_0^2 f(x) dx = \frac{x^4}{72} \Big|_0^2 = \frac{16}{72} = \frac{2}{9}$$

$$36 \left(\frac{2}{3} + \frac{2}{3} + \frac{2}{9} \right) = 14 \times 4 = 56$$

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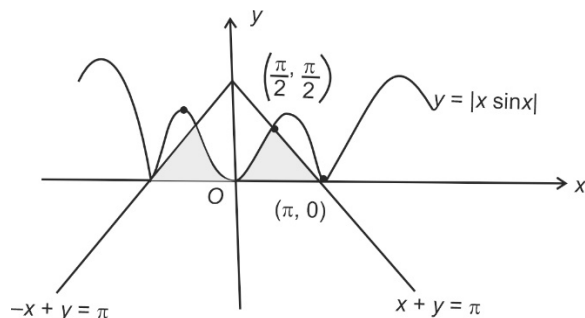


18. The area of the region $\{(x,y): y \leq \pi - |x|, y \leq |x \sin x|, y \geq 0\}$ is

- (1) $1 + \frac{\pi^2}{8}$ (2) $2 + \frac{\pi^2}{4}$
 (3) $\frac{\pi^2}{8} - 1$ (4) $4 + \frac{\pi^2}{2}$

Answer (2)

Sol.



$$\text{Area} = 2 \left[\int_0^{\frac{\pi}{2}} x \sin x \, dx + \int_{\frac{\pi}{2}}^{\pi} (\pi - x) \, dx \right] = 2 + \frac{\pi^2}{4}$$

19. Let $\int_{-2}^2 (|\sin x| + [x \sin x]) \, dx = 2(3 - \cos 2) + \beta$ where $[.]$ is the greatest integer function. Then $\beta \sin\left(\frac{\beta}{2}\right)$ equals

- (1) 1 (2) 2
 (3) 4 (4) 8

Answer (2)

Sol. $I = \int_{-2}^2 (|\sin x| + [x \sin x]) \, dx = 2 \int_0^2 (|\sin x| + [x \sin x]) \, dx$

When $x \in [0, 2]$, $0 \leq x \sin x < 2$

Let $\alpha \sin \alpha = 1$

$$\Rightarrow I = 2 \left[\int_0^2 \sin x \, dx + \int_0^{\alpha} 0 \, dx + \int_{\alpha}^2 dx \right]$$

$$\Rightarrow I = 2(3 - \cos 2) - 2\alpha \Rightarrow \beta = -2\alpha$$

$$\Rightarrow \beta \sin\left(\frac{\beta}{2}\right) = (-2\alpha) \sin(-\alpha) = 2\alpha \sin \alpha = 2$$

20. Let $y = y(x)$ be the solution of the differential equation $\frac{dy}{dx} + (1 + x + x^2)(1 - y + y^2), y(0) = \frac{1}{2}$. Then $(2y(1) - 1)$ is equal to

- (1) $\sqrt{3} \tan\left(\frac{11\sqrt{3}}{6}\right)$ (2) $\frac{\sqrt{3}}{2} \tan\left(\frac{11\sqrt{3}}{12}\right)$
 (3) $\sqrt{3} \tan\left(\frac{11\sqrt{3}}{12}\right)$ (4) $\frac{\sqrt{3}}{2} \tan\left(\frac{11\sqrt{3}}{6}\right)$

Answer (3)

Sol. $\frac{dy}{y^2 - y + 1} = (1 + x + x^2) \, dx$

$$\Rightarrow \frac{dy}{\left(y - \frac{1}{2}\right)^2 + \frac{3}{4}} = (1 + x + x^2) \, dx$$

$$\Rightarrow \frac{2}{\sqrt{3}} \tan^{-1}\left(\frac{2y-1}{\sqrt{3}}\right) = \left(\frac{x^3}{3} + \frac{x^2}{2} + x\right) + C$$

$$\therefore y(0) = \frac{1}{2} \Rightarrow C = 0$$

$$\Rightarrow \frac{2}{\sqrt{3}} \tan^{-1}\left(\frac{2y(1)-1}{\sqrt{3}}\right) = \frac{11}{6}$$

$$\Rightarrow 2y(1) - 1 = \sqrt{3} \tan\left(\frac{11\sqrt{3}}{12}\right)$$

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. A coin is tossed 8 times. If the probability that exactly 4 heads appear in the first six tosses and exactly 3 heads appear in the last five tosses is p , then $96p$ is equal to _____ .

Answer (9)

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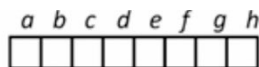
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Sol. If score = 1 if head and 0 if tail then



$$a+b+c+d+e+f=4$$

$$g+h \quad +d+e+f=3$$

- A. If $d+e+f=3$ then $a+b+c=1$ and $g+h=0$
 B. If $d+e+f=2$ then $a+b+c=2$ and $g+h=1$
 C. If $d+e+f=1$ then $a+b+c=3$ and $g+h=2$

A. ${}^3C_3 \times \left(\frac{1}{2}\right)^3 \times {}^3C_1 \left(\frac{1}{2}\right)^1 \left(\frac{1}{2}\right)^2 \times {}^2C_0 \left(\frac{1}{2}\right)^0 \left(\frac{1}{2}\right)^2$

$$= \left(\frac{1}{2}\right)^8 [{}^3C_3 \times {}^3C_1 \times {}^2C_0] = 3 \times \frac{1}{2^8}$$

B. $\left(\frac{1}{2}\right)^8 ({}^3C_2 \times {}^3C_2 \times {}^2C_1) = 18 \times \frac{1}{2^8}$

C. $\left(\frac{1}{2}\right)^8 ({}^3C_1 \times {}^3C_3 \times {}^2C_2) = 3 \times \frac{1}{2^8}$

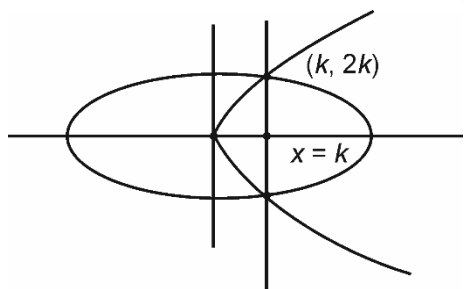
$$\Rightarrow \text{total probability} = \frac{24}{2^8} = \frac{3}{2^5} = \frac{3}{32}$$

$$\Rightarrow \frac{96 \times 3}{32} = 9$$

22. Consider the parabola $P: y^2 = 4kx$ and the ellipse $E: \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$. Let the line segment joining the points of intersection of P and E , be their latus rectums. If the eccentricity of E is e , then $e^2 + 2\sqrt{2}$ is equal to _____.

Answer (3)

Sol.



From ellipse: $ae = k$

$$\frac{b^2}{a} = 2k$$

$$\Rightarrow \frac{a^2 e}{b^2} = \frac{1}{2} \Rightarrow e = \frac{1}{2} \times \frac{b^2}{a^2}$$

Since, $e^2 = 1 - \frac{b^2}{a^2} \Rightarrow e^2 = 1 - 2e$

$$\Rightarrow e^2 + 2e = 1$$

$$(e+1)^2 = 2$$

$$\Rightarrow e = \sqrt{2} - 1$$

$$\Rightarrow e^2 = 2 + 1 - 2\sqrt{2} \Rightarrow e^2 + 2\sqrt{2} = 3$$

23. If $A = \frac{\sin 3^\circ}{\cos 9^\circ} + \frac{\sin 9^\circ}{\cos 27^\circ} + \frac{\sin 27^\circ}{\cos 81^\circ}$ and $B = \tan 81^\circ - \tan 3^\circ$, then $\frac{B}{A}$ is equal to _____.

Answer (2)

Sol. $\frac{\sin \theta}{\cos 3\theta}$

$$= \frac{2 \sin \theta \cdot \cos \theta}{2 \cos 3\theta \cdot \cos \theta}$$

$$= \frac{\sin(3\theta - \theta)}{2 \cos 3\theta \cdot \cos \theta}$$

$$= \frac{1}{2} (\tan 3\theta - \tan \theta)$$

$$\therefore A = \frac{\sin 3^\circ}{\cos 9^\circ} + \frac{\sin 9^\circ}{\cos 27^\circ} + \frac{\sin 27^\circ}{\cos 81^\circ}$$

$$= \frac{1}{2} (\tan 9^\circ - \tan 3^\circ + \tan 27^\circ - \tan 9^\circ + \tan 81^\circ - \tan 27^\circ)$$

$$A = \frac{1}{2} (\tan 81^\circ - \tan 3^\circ)$$

$$A = \frac{B}{2}$$

$$\Rightarrow \frac{B}{A} = 2$$

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24. Let $\vec{a}_k = (\tan \theta_k) \hat{i} + \hat{j}$ and $\vec{b}_k = \hat{i} - (\cot \theta_k) \hat{j}$, where

$\theta_k = \frac{2^{k-1} \pi}{2^n + 1}$, for some $n \in \mathbb{N}, n > 5$. Then the value

of $\frac{\sum_{k=1}^n |\vec{a}_k|^2}{\sum_{k=1}^n |\vec{b}_k|^2}$ is _____.

Answer (3)

Sol. $|\vec{a}_k|^2 = \tan^2 \theta_k + 1 = \sec^2 \theta_k$

$|\vec{b}_k|^2 = (1 + \cot^2 \theta_k) = \operatorname{cosec}^2 \theta_k$

$\Rightarrow \frac{\sum_{k=1}^n (\sec^2 \theta_k)}{\sum_{k=1}^n \operatorname{cosec}^2 \theta_k}, \theta_k = \frac{2^{k-1} \pi}{2^n + 1}$

$\theta = \theta_1 = \frac{\pi}{2^n + 1} \Rightarrow \theta_2 = 2\theta, \dots, \theta_n = 2^{n-1} \theta$

since, $\sec^2 \theta + \operatorname{cosec}^2 \theta = 4 \operatorname{cosec}^2 2\theta$

$\theta_{n+1} = \frac{2^n \pi}{2^n + 1} = 2^n \theta \Rightarrow \theta_{n+1} + \theta_1 = (2^n + 1)\theta = \pi$

Let $A = \sum_{k=1}^n \sec^2 \theta_k, B = \sum_{k=1}^n \operatorname{cosec}^2 \theta_k$

$\Rightarrow \sec^2 \theta_1 + \operatorname{cosec}^2 \theta_1 = 4 \operatorname{cosec}^2 2\theta_1$

$\sec^2 \theta_2 + \operatorname{cosec}^2 \theta_2 = 4 \operatorname{cosec}^2 2\theta_2$

$\sec^2 \theta_n + \operatorname{cosec}^2 \theta_n = 4 \operatorname{cosec}^2 \theta_{n+1}$

$\Rightarrow A + B = 4B, \text{ are } \operatorname{cosec}^2 \theta_{n+1} = \operatorname{cosec}^2 \theta_n$

as $\theta_{n+1} = \pi - \theta_1$

$\Rightarrow \frac{A}{B} = 3$

25. The number of points, at which the function $f(x) = \max\{6x, 2 + 3x^2\} + |x - 1| \cos \left| x^2 - \frac{1}{4} \right|, x \in (-\pi, \pi)$ is not differentiable, is _____.

Answer (3)

Sol. $f(x) = \max\{6x, 2 + 3x^2\} + |x - 1| \cos \left| x^2 - \frac{1}{4} \right|, x \in (-\pi, \pi)$

$6x$ and $2 + 3x^2$ intersects

at $x = 1 \pm \frac{1}{\sqrt{3}} \in (0, \pi)$

\Rightarrow Two such points will give two points of differentiability as $f'(x) = 6$ or $2x \Big|_{x=1 \pm \frac{1}{\sqrt{3}}}$

$\Rightarrow 2$ from $\max\{6x, 2 + 3x^2\}$

Now $|x - 1| \cos \left(\left(x - \frac{1}{2} \right) \left(x + \frac{1}{2} \right) \right)$

For $|x - 1| = 0$ at $x = 1$

Since at $x = 1, \cos \left(\left(x - \frac{1}{2} \right) \left(x + \frac{1}{2} \right) \right) \neq 0$

\Rightarrow New point of non differentiability.

Check : $\cos \left| x^2 - \frac{1}{4} \right|$ is differentiable as

$\cos(-u) = \cos(u)$ which makes

$\cos \left(\left(x^2 - \frac{1}{4} \right) \right) = \cos \left(- \left(x^2 - \frac{1}{4} \right) \right)$

\Rightarrow Only 3 points or non differentiability

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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. In a screw gauge when the circular scale is given five complete rotations it moves linearly by 2.5 mm. If the circular scale has 100 divisions, the least count of screw gauge is _____ mm.

- (1) 1×10^{-2} (2) 1×10^{-3}
(3) 5×10^{-2} (4) 5×10^{-3}

Answer (4)

Sol. Pitch length = $\frac{2.5 \text{ mm}}{5} = 0.5 \text{ mm}$

Least count = $\frac{5 \times 10^{-4}}{100} = 5 \times 10^{-6} \text{ m}$

So least count $5 \times 10^{-3} \text{ mm}$

27. The increase in the pressure required to decrease the volume (ΔV) of water is $6.3 \times 10^7 \text{ N/m}^2$. The percentage decrease in the volume is _____.

(Bulk modulus of water = $2.1 \times 10^9 \text{ N/m}^2$.)

- (1) 2% (2) 3%
(3) 6% (4) 4%

Answer (2)

Sol. We know $\left| \frac{\Delta P}{\Delta V/V} \right| = \beta$

$\Rightarrow \Delta P = \beta \left(\frac{\Delta V}{V} \right) = 6.3 \times 10^7 \text{ N/m}$

So, $\left(\frac{\Delta V}{V} \times 100 \right) = \frac{6.3 \times 10^7}{2.1 \times 10^9} \times 100 = 3\%$

28. The time taken by a block of mass m to slide down from the highest point to the lowest point on a rough inclined plane is 50% more compared to the time taken by the same block on identical inclined smooth plane. Both inclined planes are at 45° with the horizontal. The coefficient of kinetic friction between the rough inclined surface and block is _____.

- (1) $\frac{3}{4}$
(2) $\frac{2}{3}$
(3) $\frac{5}{9}$
(4) $\frac{4}{9}$

Answer (3)

Sol. For smooth inclined $\frac{1}{2} \frac{g}{\sqrt{2}} t_1^2 = l$

$\Rightarrow t_1^2 = \frac{2\sqrt{2}l}{g}$

For rough inclined $\frac{1}{2} \frac{g}{\sqrt{2}} (1-\mu)t_2^2 = l$

$\Rightarrow t_2^2 = \frac{2\sqrt{2}l}{g(1-\mu)}$

Also $t_2 = \frac{3}{2} t_1$

So, $t_2^2 = \frac{9}{4} t_1^2$

$\Rightarrow \frac{2\sqrt{2}l}{g(1-\mu)} = \frac{9}{4} \cdot \frac{2\sqrt{2}l}{g}$

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$$\Rightarrow \frac{1}{1-\mu} = \frac{9}{4}$$

$$\Rightarrow 4 = 9 - 9\mu$$

$$\Rightarrow 9\mu = 5$$

So, $\mu = \frac{5}{9}$

29. Two nuclei of mass number 3 combine with another nucleus of mass number 4 to yield a nucleus of mass number 10. If the binding energy per nucleon for the mass numbers 3, 4 and 10 are 5.6 MeV, 7.4 MeV and 6.1 MeV, respectively, then in the process, $\Delta Mc^2 = \underline{\hspace{2cm}}$ MeV.

- (1) 6.9
- (2) 7.9
- (3) 2.2
- (4) 4.3

Answer (3)

Sol. $2(x^3) + (y^4) \rightarrow (z^{10})$

$$|\Delta Mc^2| = |(6.1 \times 10) - (4 \times 7.4) - (2 \times 3 \times 5.6)|$$

$$= 61 - 29.6 - 33.6$$

$$|\Delta Mc^2| = 2.2 \text{ MeV}$$

30. A solid sphere of mass M and radius R is divided into two unequal parts. The smaller part having mass $M/8$ is converted into a sphere of radius r and the larger part is converted into a circular disc of thickness t and radius $2R$. If I_1 is moment of inertia of a sphere having radius r about an axis through its centre and I_2 is the moment of inertia of a disc about its diameter, the ratio of their moment of inertia $I_2/I_1 = \underline{\hspace{2cm}}$.

- (1) 35
- (2) 70
- (3) 140
- (4) 210

Answer (2)

Sol. $\rho = \frac{3M}{4\pi R^3}$

for smaller sphere $\frac{4}{3}\pi r^3 \rho = \frac{M}{8}$

so $r = \frac{R}{2}$... (i)

and $\pi(4R^2)t\rho = \frac{7M}{8}$

$\Rightarrow t = \frac{7R}{24}$

$I_1 = \frac{2}{5} \cdot \frac{M}{8} \cdot \frac{R^2}{4}$

$I_2 = \left(\frac{7M}{8}\right) \cdot \left[\frac{4R^2}{4} + \frac{49R^2}{24 \times 24 \times 12}\right]$

$\Rightarrow \frac{I_2}{I_1} = \frac{7MR^2}{8} \left[1 + \frac{49}{6912}\right] \times \frac{5 \times 8 \times 4}{2MR^2}$

$\Rightarrow \frac{I_2}{I_1} = 14 \times 5 \left[\frac{6961}{6912}\right] = 70.49$

Nearest answer 70.

31. The two projectiles are projected with the same initial velocities at the 15° and 30° with respect to the horizontal. The ratio of their ranges is $1 : x$. The value of x is

- (1) $\sqrt{2}$
- (2) $\sqrt{3}$
- (3) $2\sqrt{3}$
- (4) $\frac{1}{\sqrt{2}}$

Answer (2)

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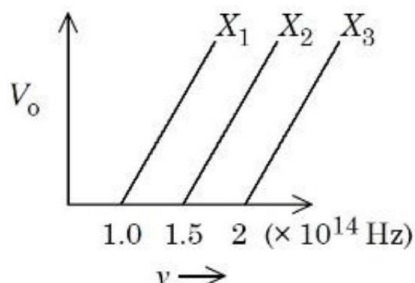
Sol. $R_1 = \frac{u^2 \sin(2 \times 15^\circ)}{g}$

$R_2 = \frac{u^2 \sin(2 \times 30^\circ)}{g}$

$\Rightarrow \frac{1}{x} = \frac{R_1}{R_2} = \frac{1 \times 2}{2 \times \sqrt{3}} = \frac{1}{\sqrt{3}}$

So, $x = \sqrt{3}$

32. The graph shows variation of stopping potential V_0 with the frequency ν of the incident radiation for three photosensitive metals X_1, X_2 and X_3 . Which metal will give out electrons with greater kinetic energy, for the same wavelength of incident radiation?



- (1) X_1
- (2) X_2
- (3) X_3
- (4) All the metals will give out photo electrons with same kinetic energies.

Answer (1)

Sol. $h\nu - \phi = eV$

$\nu = \left(\frac{h\nu}{e}\right) - \frac{\phi}{e}$

Clearly x_3 having greatest (-ve) intercept on y axis and x_1 having smallest.

So work function of (x_1) is smallest. So, x_1 will give out electron with greatest kinetic energy.

33. A slit of width a is illuminated by light of wavelength λ . The linear separation between 1st and 3rd minima in the diffraction pattern produced on a screen placed at a distance D from the slit system is ____.

- (1) $\frac{D\lambda}{a}$
- (2) $1.5 \frac{D\lambda}{a}$
- (3) $2 \frac{D\lambda}{a}$
- (4) $3 \frac{D\lambda}{a}$

Answer (3)

Sol. Minima at $y = n \left(\frac{\lambda}{a}\right)$

So, $y_1 = \frac{\lambda}{a}$ and $y_3 = \frac{3\lambda}{a}$

So, $\Delta y = \frac{2\lambda}{a}$

34. A string A of length 0.314 m and Young's modulus 2×10^{10} N/m² is connected to another string B of length and Young's modulus both twice of those of A . This series combination of strings is then suspended from a rigid support and its free end is fixed to a load of mass 0.8 kg. The net change in length of the combination is ____ mm.

(radius of both the strings is 0.2 mm and acceleration due to gravity = 10 m/s²)
(Mass of both strings is to be neglected as compared to the mass of load)

- (1) 3
- (2) 2
- (3) 1.9
- (4) 1

Answer (2)

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Sol. $\Delta l = \Delta l_1 + \Delta l_2$

$$\Rightarrow \Delta L = \frac{F_1 l_1}{A_1 y_1} + \frac{F_2 l_2}{A_2 y_2}$$

$$\Delta l = \frac{F l}{A y} + \frac{F l}{A y} = \frac{2 F l}{A y}$$

$$\text{So, } \Delta l = \frac{2 \times 8 \times 0.314}{3.14 \times 4 \times 10^{-8} \times 2 \times 10^{10}} = 2 \times 10^{-3} \text{ m}$$

So $\Delta l = 2 \text{ mm}$

35. One gas of n_1 mole of molecules at temperature T_1 , volume V_1 , and pressure P_1 , and another gas of n_2 mole of molecules at temperature T_2 , volume V_2 , and pressure P_2 , are mixed resulting in pressure P and volume V of the mixture. The temperature of the mixture is _____.

(1) $\frac{(T_1 + T_2)}{2}$

(2) $\frac{T_1 T_2 P V}{(T_2 P_1 V_1 + T_1 P_2 V_2)}$

(3) $\frac{(T_2 P_1 V_1 + T_1 P_2 V_2)}{(T_1 T_2 P V)}$

(4) $\frac{|T_1 - T_2|}{2}$

Answer (2)

Sol. $P_1 V_1 = n_1 R T_1$ and $P_2 V_2 = n_2 R T_2$

$$P V = \left(\frac{P_1 V_1}{R T_1} + \frac{P_2 V_2}{R T_2} \right) R T$$

$$\text{So, } P V = \frac{(P_1 V_1 T_2 + P_2 V_2 T_1)}{T_1 T_2} T$$

$$\Rightarrow T = \frac{P V (T_1 T_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$$

36. An ideal gas undergoes a process maintaining relation between pressure (P) and volume (V) as

$$P = P_0 \left[1 + \left(\frac{V_0}{V} \right)^2 \right]^{-1}, \text{ where } P_0 \text{ and } V_0 \text{ are}$$

constants. If two samples A and B (two moles each) with initial volumes V_0 and $3V_0$ respectively undergo above mentioned process and attain same pressure, then the difference at the temperatures of these samples, $T_B - T_A$ is _____.

(R = gas constant)

(1) $\frac{9 P_0 V_0}{8 R}$

(2) $\frac{11 P_0 V_0}{10 R}$

(3) $\frac{7 P_0 V_0}{6 R}$

(4) $\frac{13 P_0 V_0}{11 R}$

Answer (2)

Sol. $P = P_0 \left[1 + \left(\frac{V_0}{V} \right)^2 \right]^{-1}$

for sample (A) $P_A = P_0 (2)^{-1} = P_0 / 2$ and $n_1 = 2$

$$\text{So, } \frac{P_0 V_0}{2} = 2 R T_A$$

For sample (B) $P_B = P_0 \left[1 + \frac{1}{9} \right]^{-1} = \frac{9 P_0}{10}$ and $n_2 = 2$

$$\text{So, } \frac{9 P_0}{10} \cdot 3 V_0 = 2 R T_B$$

Initial temperature difference $T_B - T_A = \frac{11}{10} \frac{P_0 V_0}{R}$

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37. A voltmeter with internal resistance of $x\Omega$ can be used to measure upto 20 V. In order to increase its measuring range to 30 V, the required modification is to ____.

- (1) connect resistor of $\frac{x}{2}\Omega$, in series with voltmeter.
- (2) connect resistor of $\frac{x}{2}\Omega$, in parallel to voltmeter.
- (3) connect a resistor of $x\Omega$ in series with voltmeter.
- (4) connect resistor of $2x\Omega$ in parallel to voltmeter.

Answer (1)

Sol. $x = \left(\frac{20}{I_c}\right)$

So, $(x + R)i_c = 30$

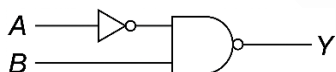
$\Rightarrow (x + R)20 = 30x$

$\Rightarrow 2x + 2R = 3x \Rightarrow x = 2R$

$\Rightarrow R = \frac{x}{2}$

so connect $R = \frac{x}{2}\Omega$ resistor in series with voltmeter.

38. Two 4 bits binary numbers, $A = 1101$ and $B = 1010$ are given in the inputs of a logic circuit shown in figure below. The output (Y) will be:



- (1) $Y = 1101$
- (2) $Y = 0010$
- (3) $Y = 0111$
- (4) $Y = 1000$

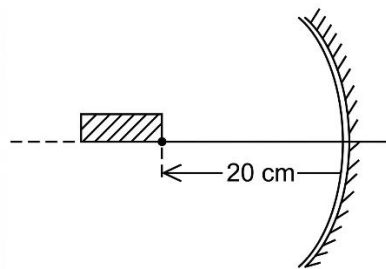
Answer (1)

Sol. $Y = \overline{A} \cdot B = A + \overline{B}$

So, for $A(1101)$ and $B(1010)$

Y will be 1101

39. A rod of length 10 cm lies along the principle axis of a concave mirror of focal length 10 cm as shown in figure. The length of the image is ____ cm.



- (1) 2.5
- (2) 5
- (3) 7.5
- (4) 7

Answer (2)

Sol. $\frac{1}{v_1} - \frac{1}{20} = -\frac{1}{10}$

$\Rightarrow \frac{1}{v_1} = -\frac{1}{10} + \frac{1}{20} = -\frac{1}{20} \Rightarrow v_1 = -20$ cm

Now $\frac{1}{v_2} - \frac{1}{30} = -\frac{1}{10}$

$\Rightarrow \frac{1}{v_2} = -\frac{1}{10} + \frac{1}{30} = -\frac{2}{30}$

$v_2 = -15$ cm

So, $|v_1| - |v_2| = 5$ cm

40. A parallel plate air capacitor is connected to a battery. The plates are pulled apart at uniform speed v . If x is the separation between the plates at any instant, then the time rate of change of electrostatic energy of the capacitor is proportional to x^α , where α is ____.

- (1) -2
- (2) 1
- (3) -1
- (4) 2

Answer (1)

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Sol. $C = \frac{A\epsilon_0}{d} = \frac{A\epsilon_0}{x}$

$E = \frac{1}{2} \frac{A\epsilon_0}{x} \cdot V^2$

So, $\left(\frac{dE}{dt}\right) = \frac{1}{2} A\epsilon_0 V^2 \left(\frac{-1}{x^2}\right) \frac{dx}{dt}$

$\Rightarrow \left|\frac{dE}{dt}\right| = \frac{A\epsilon_0 V^2}{2x^2} v$

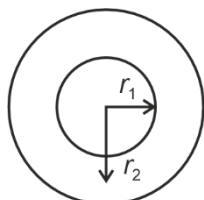
Clearly $\left(\frac{dE}{dt}\right) \propto x^{-2}$

41. An insulated wire is wound so that it forms a flat coil with $N = 200$ turns. The radius of the innermost turn is $r_1 = 3$ cm, and of the outermost turn $r_2 = 6$ cm. If 20 mA current flows in it then the magnetic moment will be $\alpha \times 10^{-2}$ A.m². The value of α is

- (1) 4.4
- (2) 2.64
- (3) 3.25
- (4) 1.2

Answer (2)

Sol. Number of turns per unit Length is $\frac{200}{3} \times 100$



At distance x if dx width is taken

Then $\int dP_m = \int l \cdot \pi x^2 \cdot \frac{2 \times 10^4}{3} dx$

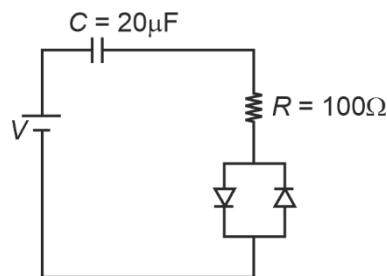
$\Rightarrow |\bar{P}_m| = \frac{l \times 2 \times 10^4}{3} \pi \cdot \frac{x^3}{3} \Big|_{3\text{cm}}^{6\text{cm}}$

$\Rightarrow |\bar{P}_m| = \frac{20 \times 10^{-3} \times 2 \times 10^4}{3 \times 3} \times \pi \times 189 \times 10^{-6}$

$|\bar{P}_m| = 0.0264 \text{ Am}^2 \approx 2.64 \times 10^{-2} \text{ Am}^2$

So, $\alpha = 2.64$

42. Consider a circuit consisting of a capacitor ($20\mu\text{F}$), resistor (100Ω) and two identical diodes as shown in figure. The resistance of diode under forward biasing condition is 10Ω . The time constant of the circuit is $\alpha \times 10^{-3}$ s. The value of α is _____.



- (1) 2.2
- (2) 2.0
- (3) 2.1
- (4) 2.4

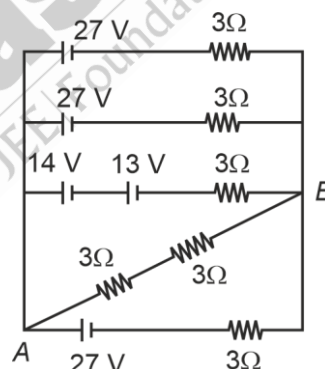
Answer (1)

Sol. Clearly $R_{eq} = 100 + 10 = 110 \Omega$

And $\tau = R_{eq} C = 110 \times 20 \times 10^{-6} = 2.2 \times 10^{-3}$ s

$\alpha = 2.2$

43. The voltage and the current between A and B points shown in the circuit are _____.



- (1) 24 V, 12 A
- (2) 24 V, 4 A
- (3) 18 V, 12 A
- (4) 27 V, 4 A

Answer (2)

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Sol. $\vec{F} = (5\hat{i} + 2\hat{j} + 2\hat{k})$

$$\vec{\Delta r} = \frac{25(3\hat{i} - 4\hat{j})}{5} = 5(3\hat{i} - 4\hat{j})$$

So, $\Delta w = \vec{F} \cdot \vec{\Delta r} = 5(15 - 8) = 35$ Joule

47. The surface tension of a soap solution is 3.5×10^{-2} N/m. The work required to increase the radius of a soap bubble from 1 cm to 2 cm is $\alpha \times 10^{-6}$ J. The value of α is _____.

$$\left(\pi = \frac{22}{7} \right)$$

Answer (132)

Sol. $\Delta w = (4\pi R_2^2 - 4\pi R_1^2) T$

$$\Rightarrow \Delta w = 4\pi T(4 - 1) \times 10^{-4} = 4 \times \frac{22}{7} \times 3 \times 3.5 \times 10^{-6}$$

$$\Delta w = 132 \times 10^{-6} \text{ Joule}$$

48. The velocity of a particle executing simple harmonic motion along x-axis is described as $v^2 = 50 - x^2$, where x represents displacement. If the time period of motion is $\frac{x}{7}$ s, the value of x is _____.

Answer (44)

Sol. For $x = 0$; $v_0 = 5\sqrt{2}$ and for $v = 0$; $A = 5\sqrt{2}$

$$\text{Clearly } \frac{1}{2}k A^2 = \frac{1}{2}mv_0^2 \Rightarrow \frac{k}{m} = \omega^2 = \left(\frac{v_0}{A}\right)^2 = 1$$

So, $\omega = 1$

$$\Rightarrow T = \frac{2\pi}{\omega} = \frac{2 \times 22}{7 \times 1} = \frac{44}{7} \text{ sec.}$$

49. A body of mass 2 kg begins to move under the influence of time dependent force $\vec{F} = (2t\hat{i} + 6t^2\hat{j})$ N, where \hat{i} and \hat{j} are unit vectors along x and y-axis respectively. The power produced by the force at $t = 2$ s is _____ W.

Answer (200)

Sol. $F = (2t\hat{i} + 6t^2\hat{j})$ and $m = 2$ kg

$$\text{So, } a_x = \frac{dv_x}{dt} = t$$

$$\Rightarrow v_x = \frac{t^2}{2}$$

$$\text{and } a_y = \frac{dv_y}{dt} = 3t^2 \Rightarrow v_y = t^3$$

So, at $t = 2$ sec.

$$\vec{v} = (2\hat{i} + 8\hat{j}) \text{ and } \vec{F} = (4\hat{i} + 24\hat{j})$$

$$\text{So, } \vec{F} \cdot \vec{v} = 8 + 192 = 200 \text{ watt}$$

50. An inductor of 10 mH, capacitor of $0.1 \mu\text{F}$ and a resistor of 100Ω are connected in series across an a.c power supply 220 V, 70 Hz. The power factor of the given circuit is 0.5. The difference in the inductive reactance and capacitance reactance is $\sqrt{3} \alpha \Omega$. The value of α is _____.

Answer (100)

Sol. Power factor = $\cos\theta = \frac{R}{\sqrt{R^2 + X^2}} = \frac{1}{2}$

$$\text{So, } 4R^2 = R^2 + X^2 \Rightarrow 3R^2 = X^2$$

$$\text{Here, } X = |X_L - X_C|$$

$$\Rightarrow 3 \times (100)^2 = 3\alpha^2$$

$$\Rightarrow \alpha = 100$$

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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. Number of moles and number of molecules in 1.4187 L of SO_2 at STP respectively are

- (1) 0.1266 ; 3.812×10^{22}
- (2) 0.0633; 3.812×10^{22}
- (3) 0.1266; 7.6238×10^{22}
- (4) 0.0633; 7.6238×10^{22}

Answer (2)

Sol. Number of moles of $\text{SO}_2 = \frac{1.4187}{22.4} = 0.0633$ moles

$$\begin{aligned} \text{Number of molecules} &= 0.0633 \times 6.022 \times 10^{23} \\ &= 0.0381 \times 10^{23} \\ &= 3.81 \times 10^{22} \end{aligned}$$

52. What is the ratio of wave number of first line (lowest energy line) of Balmer series of H atomic spectrum to first line of its Brackett series?

- (1) 5 : 1
- (2) 5 : 0.81
- (3) 5 : 1.75
- (4) 5 : 27

Answer (3)

Sol. $\bar{\nu} = R \times Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$

First line of Balmer ($3 \rightarrow 2$)

First line of Brackett ($5 \rightarrow 4$)

$$\frac{\bar{\nu}_{\text{Balmer}}}{\bar{\nu}_{\text{Brackett}}} = \frac{\frac{1}{2^2} - \frac{1}{3^2}}{\frac{1}{4^2} - \frac{1}{5^2}} = \frac{\frac{5}{36}}{\frac{9}{400}} = \frac{5 \times 400}{36 \times 9} = \frac{5}{0.81}$$

53. Which of the following is correct set of 4 quantum numbers of 19^{th} electron in Chromium (Atomic number = 24) in accordance with Aufbau principle?

- (1) $n = 3, l = 2, m = +2, s = +\frac{1}{2}$
- (2) $n = 3, l = 2, m = -2, s = +\frac{1}{2}$
- (3) $n = 4, l = 1, m = 0, s = +\frac{1}{2}$
- (4) $n = 4, l = 0, m = 0, s = +\frac{1}{2}$

Answer (4)

Sol. Atomic number of Cr = 24

19^{th} electron will be in $4s^1$

Quantum number for this $n = 4, l = 0, m = 0, s = +\frac{1}{2}$

54. Given below are two statements :

Statement I : For an ideal gas, heat capacity at constant volume is always greater than the heat capacity at constant pressure.

Statement II : In a constant volume process, no work is produced and all the heat withdrawn goes into the chaotic motion and is reflected by a temperature increase of the ideal gas.

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) Both Statement I and Statement II are false
- (3) Statement I is true but Statement II is false
- (4) Statement I is false but Statement II is true

Answer (4)

Sol. $C_p - C_v = R > 0$

$C_p > C_v$

If $V = \text{const. } w = 0$

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55. At $T(K)$, the equilibrium constant of $A_2(g) + B_2(g) \rightleftharpoons C(g)$ is 2.7×10^{-5} .

What is the equilibrium constant for $\frac{1}{3} A_2(g) + \frac{1}{3} B_2(g) \rightleftharpoons \frac{1}{3} C(g)$ at the same temperature?

- (1) $(2.7 \times 10^{-5})^3$ (2) 6×10^{-2}
 (3) $\sqrt{2.7 \times 10^{-5}}$ (4) 3×10^{-2}

Answer (4)

Sol. $A_2(g) + B_2(g) \rightleftharpoons C(g)$ $K_{eq} = 2.7 \times 10^{-5}$

For new reaction,

$$K = \sqrt[3]{2.7 \times 10^{-5}}$$

$$= \sqrt[3]{27 \times 10^{-6}} = 3 \times 10^{-2}$$

56. In order to oxidise a mixture of 1 mole each of FeC_2O_4 , $Fe_2(C_2O_4)_3$, $FeSO_4$ and $Fe_2(SO_4)_3$ in acidic medium, the number of moles of $KMnO_4$ required is

- (1) 3 (2) 2
 (3) 5 (4) 7

Answer (2)

Sol. Only FeC_2O_4 , $Fe_2(C_2O_4)_3$ and $FeSO_4$ will be oxidised.

$$n \times n\text{-factor} = 3 \times 1 + 6 \times 1 + 1 \times 1$$

$$n \times 5 = 10$$

$$n = 2$$

57. Consider the first order reaction $R \rightarrow P$.

The fraction of molecules decomposed in the given first order reaction can be expressed as

- (1) $1 - e^{k_1t}$ (2) $1 + e^{k_1t}$
 (3) $1 + e^{-k_1t}$ (4) $1 - e^{-k_1t}$

Answer (4)

Sol. $R \rightarrow P$

For 1st order,

$$A_t = A_0 e^{-k_1t}$$

$$\text{Amount decomposed} = A_0 - A_0 e^{-k_1t}$$

$$\text{Fraction decomposed} = \frac{A_0 - A_0 e^{-k_1t}}{A_0} = 1 - e^{-k_1t}$$

58. A monoatomic anion (A^-) has 45 neutrons and 36 electrons. Atomic mass, group in the periodic table and physical state at room temperature of the element (A) respectively are

- (1) 80, 17, liquid (2) 81, 16, solid
 (3) 80, 16, gas (4) 81, 15, gas

Answer (1)

Sol. $n = 45$

Number of e^- in atom (A) = 35

Number of protons = 35

Atomic mass = 35 + 45 = 80

This is bromine which is liquid.

59. Given below are two statements :

Statement I : The covalency of oxygen is generally two but it can exceed upto four. The oxidation state of oxygen in SO_2 is -2 and in OF_2 it is $+2$.

Statement II : The anomalous behaviour of oxygen when compared to the other elements of group 16 is due to its small size and high electronegativity.

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) Both Statement I and Statement II are false
 (3) Statement I is true but Statement II is false
 (4) Statement I is false but Statement II is true

Answer (4)

Sol. S-I : Oxygen can extend its covalency upto 3 only. (Incorrect)

S-II : Oxygen has small size and high EN. (Correct)

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60. The correct statements among the following are
- Mo(VI) and W(VI) are less stable than Cr(VI).
 - Ce⁴⁺ and Tb⁴⁺ are oxidant while Eu²⁺ and Yb²⁺ are reductant.
 - Cm and Am have seven unpaired electrons.
 - Actinoid contraction is greater from element to element than lanthanoid contraction.

Choose the **correct** answer from the options given below.

- (1) A and B only (2) C and D only
(3) B and D only (4) A and C only

Answer (3)

- Sol.** (A) Correct order of stability
W(+6) > Mo(+6) > Cr(+6)
- (B) Lanthanoid have tendency to go to +3. (Correct)
- (C) Curium ⇒ [Rn]5f⁷6d¹7s² 8 unpaired e⁻
Americium ⇒ [Rn]5f⁷6d⁰7s² 7 unpaired e⁻
- (D) Actinoids have 5f which have very poor shielding. (Correct)

61. **Correct** statements from the following are
- Potassium dichromate is an oxidising agent and it oxidises FeSO₄ to Fe₂(SO₄)₃ in acidic medium.
 - Sodium dichromate can be used as primary standard in volumetric estimation.
 - CrO₄²⁻ and Cr₂O₇²⁻ are interconvertible in aqueous solution by varying the pH of the solution.
 - Cr – O – Cr bond angle in Cr₂O₇²⁻ is 126°.

Choose the correct answer from the options given below.

- (1) A, B and C Only (2) A, C and D Only
(3) A and C Only (4) B and D Only

Answer (2)

- Sol.** (A) K₂Cr₂O₇ is strong oxidising agent
(B) Na₂Cr₂O₇ is not primary standard, K₂Cr₂O₇ is
(C) $\text{CrO}_4^{2-} \xrightleftharpoons[\text{OH}^-]{\text{H}^+} \text{Cr}_2\text{O}_7^{2-}$
(D) Bond angle is 126°
62. Match the **LIST-I** with **LIST-II**.

List-I		List-II	
Complex ion		Calculated spin only magnetic moment (BM)	
A.	[Cr(H ₂ O) ₆] ²⁺	I.	3.87
B.	[Co(H ₂ O) ₆] ²⁺	II.	5.92
C.	[Cu(H ₂ O) ₆] ²⁺	III.	4.90
D.	[Mn(H ₂ O) ₆] ²⁺	IV.	1.73

Choose the **correct** answer from the options given below.

- (1) A-I, B-III, C-IV, D-II (2) A-II, B-I, C-III, D-IV
(3) A-IV, B-II, C-I, D-III (4) A-III, B-I, C-IV, D-II

Answer (4)

- Sol.** H₂O is WFL for all these
- [Cr(H₂O)₆]²⁺ 3d⁴, μ = √4(4+2) BM, A-III
[Co(H₂O)₆]²⁺ 3d⁷, μ = √3(3+2) BM = 3.87BM, B-I
[Cu(H₂O)₆]²⁺ 3d⁹, μ = √1(1+2) BM = 1.73BM, C-IV
[Mn(H₂O)₆]²⁺ 3d⁵, μ = √5(5+2) BM = 5.92BM, D-II

63. Increasing order of electron withdrawing power of following functional groups is
- CN
 - COOH
 - NO₂
 - I

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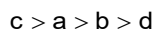
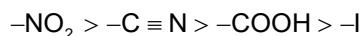
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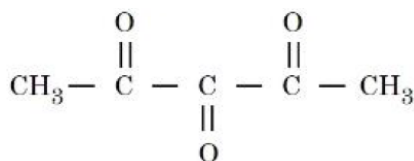
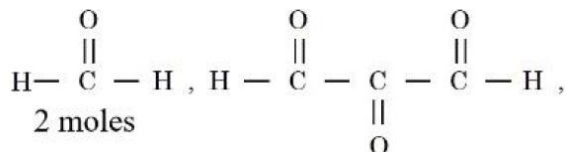
- (1) $c < b < d < a$ (2) $c < a < b < d$
 (3) $d < b < a < c$ (4) $a < b < c < d$

Answer (3)

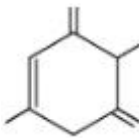
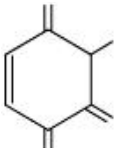
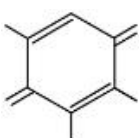
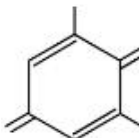
Sol. Correct order



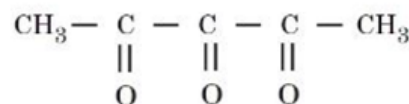
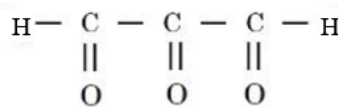
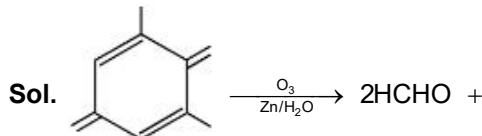
64. An alkene (X) on ozonolysis followed by reduction gives following products.



The alkene (X) is

- (1) 
 (2) 
 (3) 
 (4) 

Answer (4)



65. Match the LIST-I with LIST-II.

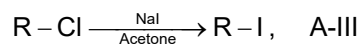
List-I		List-II	
Name of reaction		Reagent or catalyst used	
A.	Finkelstein reaction	I.	SbF ₃
B.	Swarts reaction	II.	Na, dry ether
C.	Sandmeyer's reaction	III.	NaI
D.	Fittig reaction	IV.	Cu ₂ Cl ₂

Choose the **correct** answer from the options given below.

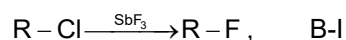
- (1) A-I, B-IV, C-III, D-II
 (2) A-III, B-I, C-IV, D-II
 (3) A-IV, B-II, C-I, D-III
 (4) A-I, B-III, C-II, D-IV

Answer (2)

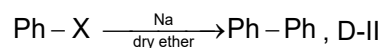
Sol. Finkelstein Reaction



Swarts Reaction



Fittig Reaction



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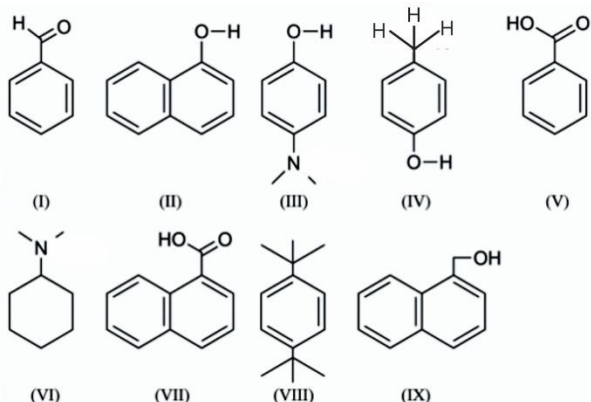
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66. Amongst the following, the total number of compounds soluble in aqueous NaOH at room temperature is



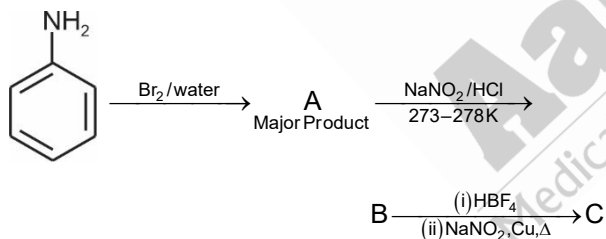
- (1) 5
(2) 4
(3) 6
(4) 3

Answer (1)

Sol. Compound which have less pK_a than aqueous NaOH are soluble in it.

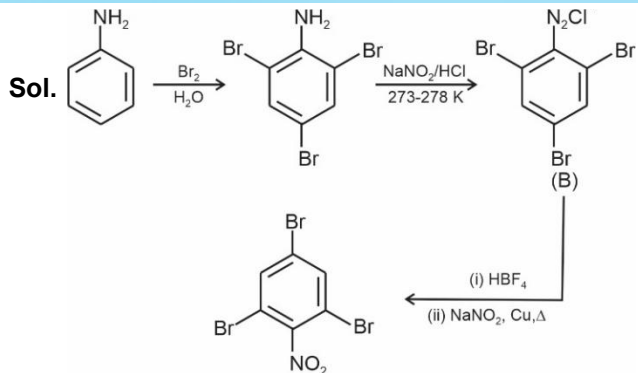
II, III, IV, V, VII are soluble.

67. Product C of the following reaction sequence will be



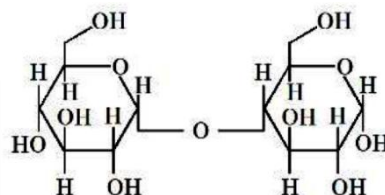
- (1) 1-Bromo-4-nitrobenzene
(2) 1, 3, 5-Tribromo-2-nitrobenzene
(3) 4-Bromo-1-nitrobenzene
(4) 1, 3, 5-Tribromobenzene

Answer (2)



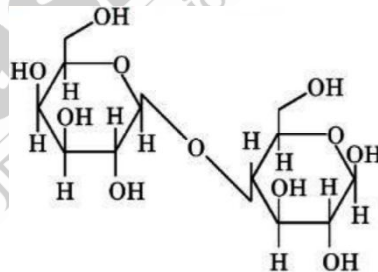
68. Given below are two statements :

Statement I : The structure of Maltose is given below.



Maltose is a non-reducing sugar.

Statement II : The structure of Lactose is given below.



Lactose is a reducing sugar.

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) Both Statement I and Statement II are false
(3) Statement I is true but Statement II is false
(4) Statement I is false but Statement II is true

Answer (4)

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Sol. Maltose and lactose are reducing sugar

Statement I false.

Statement II true.

69. Match the LIST-I with LIST-II.

List-I		List-II	
Name of amino acid		One letter symbol/type	
A.	Arginine	I.	D/Non-essential
B.	Aspartic acid	II.	R/Essential
C.	Lysine	III.	E/Non-essential
D.	Glutamic acid	IV.	K/Essential

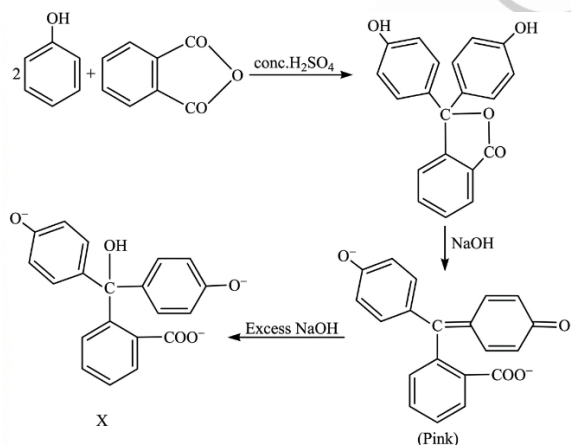
Choose the **correct** answer from the options given below.

- (1) A-II, B-I, C-IV, D-III (2) A-IV, B-III, C-II, D-I
 (3) A-III, B-IV, C-I, D-II (4) A-II, B-IV, C-I, D-III

Answer (1)

Sol. Arginine - R/Essential
 Aspartic acid - D/Non-essential
 Lysine - K/Essential
 Glutamic acid - E/Non-essential

70. Identify the colour of compound 'X' in the sequence of the reaction.



- (1) Violet (2) Green
 (3) Red (4) Colourless

Answer (1)

Sol. Violet, due to more resonance, colour will intensify.

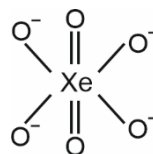
SECTION - B

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. According to Lewis theory, the total number of σ bond-pairs and lone pair of electrons around the central atom of XeO_6^{4-} ion is ____.

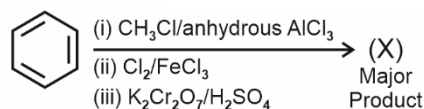
Answer (6)

Sol. XeO_6^{4-}



$$\sigma + l.p = 6 + 0$$

72. Consider the following sequence of reactions to give the major product (X).

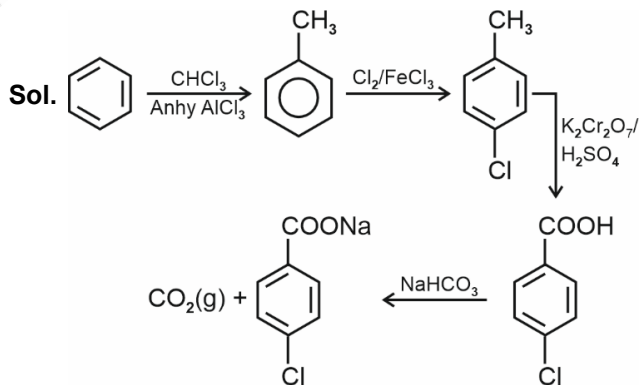


P g of the major product (X) formed is reacted with NaHCO_3 solution to liberate a gas which occupied 11.2 dm^3 at STP.

$$P = \text{____ g.}$$

(Given molar mass in g mol^{-1} H : 1, C : 12, O : 16, Cl : 35.5)

Answer (78)



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$$\text{Moles of CO}_2 \text{ evolved} = \frac{11.2}{22.4} = 0.5 \text{ mole}$$

$$\text{Mass of (X)} = 0.5 \times 156.5 = 78.25 \text{ g}$$

73. 2.0 g of a bromo hydrocarbon (X) was subjected to Carius analysis, gave 3.36 g of AgBr. The percentage of carbon in the compound (X) is 26.7%. Total number of carbon atoms in the empirical formula for compound (X) is ____.

(Given molar mass in g mol^{-1} H : 1, C : 12, Br : 80, Ag : 108)

Answer (5)

Sol. Mass of Br = $\frac{80}{188} \times 3.36 \approx 1.43 \text{ g}$

$$\begin{aligned} \text{Mass of C in compound} &= \frac{26.7}{100} \times 2 \\ &= 0.534 \text{ g} \end{aligned}$$

$$\begin{aligned} \text{Mass of H} &= 2 - (0.534 + 1.43) \\ &= 0.036 \end{aligned}$$

	Mass	Moles	Simple ratio
C	0.534	0.0445	5
H	0.036	0.036	4
Br	1.43	0.0179	2

74. The pH of a solution obtained by mixing 5 mL of 0.1 M NH_4OH solution with 250 mL of 0.1 M NH_4Cl solution is $\text{____} \times 10^{-2}$. (Nearest integer)

Given : $\text{pK}_b (\text{NH}_4\text{OH}) = 4.74$

$$\log 2 = 0.30$$

$$\log 3 = 0.48$$

$$\log 5 = 0.70$$

Answer (644)

Sol. $\text{pH} = \text{pK}_b + \log \frac{[\text{NH}_4\text{Cl}]}{[\text{NH}_4\text{OH}]}$

$$= 4.74 + \log \frac{25}{0.5}$$

$$= 4.74 + \log 50$$

$$= 4.74 + 1 + 0.7$$

$$= 6.44 = 644 \times 10^{-2}$$

75. A non-volatile, non-electrolyte solid solute when dissolved in 40 g of a solvent, the vapour pressure of the solvent decreased from 760 mm Hg to 750 mm Hg. If the same solution boils at 320 K, then the number of moles of the solvent present in the solution is _____. (Nearest integer)

[Given : boiling point of the pure solvent = 319.5 K, K_b of the solvent = $0.3 \text{ K kg mol}^{-1}$]

Answer (5)

Sol. $\Delta T_b = 0.5 = \text{K}_b m$

$$0.5 = 0.3 m$$

$$\frac{5}{3} = m = \frac{n_{\text{solute}}}{0.04}$$

$$\frac{P^\circ - P_s}{P_s} = \frac{n_{\text{solute}}}{n_{\text{solvent}}}$$

$$\frac{10}{750} = \frac{1}{75} = \frac{0.2}{n_{\text{solvent}}}$$

$$n_{\text{solvent}} = 5 \text{ moles}$$



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100 Overall



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BAINGAHA
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100 Overall



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