JEE (Main) 2022
PAPER-1 (B.E./B. TECH.)

COMPUTER BASED TEST (CBT)
Questions & Solutions

Date: 25 June, 2022 (SHIFT-2) | TIME: (3.00 p.m. to 6.00 p.m)
Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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This solution was downloaded from Resonance JEE (MAIN) 2022 Solution portal
1. Let $A = \{x \in \mathbb{R} : |x + 1| < 2\}$ and $B = \{x \in \mathbb{R} : |x - 1| \geq 2\}$. Then which one of the following statements is NOT true?

(A) $A - B = (-1, 1)$

(B) $B - A = \mathbb{R} - (-3, 1)$

(C) $A \cap B = (-3, -1)$

(D) $A \cup B = \mathbb{R} - [1, 3)$

**NTA Ans.** (B)  
**Reso Ans.** (B)  
**Sol.**

$|x + 1| < 2 \Rightarrow -2 < x + 1 < 2 \Rightarrow x \in (-3, 1) = A$

$|x - 1| \geq 2 \Rightarrow x - 1 \leq -2 \vee x - 1 \geq 2$

$\Rightarrow x \leq -1 \vee x \geq 3 \Rightarrow x \in (-\infty, -1] \cup [3, \infty) = B$

$A = (-3, 1)$  
$B = (-\infty, -1] \cup [3, \infty)$

$A' = (-\infty, -3] \cup [1, \infty)$  
$B' = (-1, 1)$

$A - B = A \cap B' = (-1, 1)$

$B - A = A' \cap B = (-\infty, -3] \cup [3, \infty)$

$A \cup B = (-\infty, 1] \cup [3, \infty)$

$A \cap B = (-3, -1]$

2. Let $a, b \in \mathbb{R}$ be such that the equation $ax^2 - 2bx + 15 = 0$ has a repeated root $\alpha$. If $\alpha$ and $\beta$ are the roots of the equation $x^2 - 2bx + 21 = 0$, then $\alpha^2 + \beta^2$ is equal to:

(A) 37  
(B) 58  
(C) 68  
(D) 92

**NTA Ans.** (B)  
**Reso Ans.** (B)  
**Sol.**

Equation $ax^2 - 2bx + 15 = 0$

Sum of root $\alpha + \alpha = \frac{2b}{a} \Rightarrow \alpha = \frac{b}{a}$

Product of root $\alpha \cdot \alpha = \frac{15}{a} \Rightarrow \alpha = \sqrt{\frac{15}{a}}$

since roots are repeated $\Rightarrow D = 0$

$\Rightarrow 4b^2 - 4a \cdot 15 = 0 \Rightarrow b^2 = 15a = \frac{15^2}{\alpha^2} \Rightarrow b = \pm \frac{15}{\alpha}$

Equation $x^2 - 2bx + 21 = 0$

Sum of root $\alpha + \beta = 2b.$

Product of root $\alpha \beta = 21$

$\alpha + \frac{21}{\alpha} = 2 \left( \frac{15}{\alpha} \right) \Rightarrow \alpha^2 = 9 \Rightarrow \alpha = \pm 3$

$\Rightarrow \beta = \pm 7$

The value of $\alpha^2 + \beta^2 = 9 + 49 = 58$
Let \( z_1 \) and \( z_2 \) be two complex numbers such that \( \overline{z_1} = iz_2 \) and \( \arg\left(\frac{z_1}{z_2}\right) = \pi \). Then

**Question:**

A. \( \arg z_2 = \frac{\pi}{4} \)

B. \( \arg z_2 = -\frac{3\pi}{4} \)

C. \( \arg z_1 = \frac{\pi}{4} \)

D. \( \arg z_1 = -\frac{3\pi}{4} \)

**NTA Ans.** (C)  
**Reso Ans.** (C)

**Sol.**

\[
\arg \left(\frac{z_1}{z_2}\right) = \pi \Rightarrow \arg z_1 - \arg z_2 = \pi \\
\Rightarrow \arg z_1 + \arg z_2 = \pi \quad \text{..........(1)}
\]

\[
\therefore \quad \overline{z_1} = iz_2 \Rightarrow z_1 = -iz_2 \\
\Rightarrow \arg z_1 = \arg(-iz_2) \\
\Rightarrow \arg z_1 = \arg(-i) + \arg z_2 \\
\Rightarrow \arg z_1 - \arg z_2 = -\frac{\pi}{2} \quad \text{..........(2)}
\]

From (1) and (2) \( \arg z_1 = \frac{\pi}{4} \) and \( \arg z_2 = -\frac{3\pi}{4} \)

The system of equations

\[
-kx + 3y - 14z = 25 \\
-15x + 4y - kz = 3 \\
-4x + y + 3z = 4
\]

**Question:** is consistent for all \( k \) in the set

A. \( \mathbb{R} \)

B. \( \mathbb{R} - \{-11, 13\} \)

C. \( \mathbb{R} - \{13\} \)

D. \( \mathbb{R} - \{-11, 11\} \)
NTA Ans. (D)  
Reso Ans. (D)  
Sol.  
\[
\begin{vmatrix} 
-3 & 3 & -14 \\
-15 & 4 & -k \\
-4 & 1 & 3 \\
\end{vmatrix} 
\neq 0
\]
\[-k^2 + 121 \neq 0 \Rightarrow k \neq 11, 11
\]
\[R = (-11, 11)\]

5

\[
\lim_{x \to \frac{\pi}{2}} \tan^2 x \left(2 \sin^2 x + 3 \sin x + 4 \right)^{\frac{1}{2}} - \left(\sin^2 x + 6 \sin x + 2 \right)^{\frac{1}{2}}
\]
is equal to

(A) \(\frac{1}{12}\)  
(B) \(-\frac{1}{18}\)  
(C) \(-\frac{1}{12}\)  
(D) \(\frac{1}{6}\)

NTA Ans. (A)  
Reso Ans. (A)  

The area of the region enclosed between the parabolas \(y^2 = 2x - 1\) and \(y^2 = 4x - 3\) is

(A) \(\frac{1}{3}\)  
(B) \(\frac{1}{6}\)  
(C) \(\frac{2}{3}\)  
(D) \(\frac{3}{4}\)

NTA Ans. (A)  
Reso Ans. (A)  

Sol.  

When \(y^2 = 2x - 1\)  
\(y^2 = 4x - 3\)
\[4x - 3 = 2x - 1\]
\[x = 1, y = \pm 1\]
Point of intersection are (1, 1), (1, -1)
Required area = \( \frac{1}{2} (x_1 - x_2) \) dy = \( \frac{1}{2} \left( \frac{y^2 + 3}{4} - \frac{y^2 + 1}{2} \right) \) dy = \( \frac{1}{2} \left( \frac{-y^2 + 1}{4} \right) \) dy

= \( \frac{1}{4} \left( \frac{-y^3}{3} + y \right) \) = \( \frac{1}{4} \left( \left( -\frac{1}{3} \right) - \left( \frac{1}{3} \right) \right) = \frac{1}{3} \)

The coefficient of \( x^{101} \) in the expression

\((5 + x)^{500} + x(5 + x)^{499} + x^2(5 + x)^{498} + \ldots + x^{500}, x > 0\), is

(A) \( 501 \binom{501}{101} (5)^{399} \)  
(B) \( 501 \binom{501}{100} (5)^{400} \)  
(C) \( 501 \binom{501}{100} (5)^{400} \)  
(D) \( 500 \binom{501}{10} (5)^{399} \)

The sum \( 1 + 2 \cdot 3 + 3 \cdot 3^2 + \ldots + 10 \cdot 3^9 \) is equal to:

A \( \frac{2 \cdot 3^{12} + 10}{4} \)  
B \( \frac{19 \cdot 3^{10} + 1}{4} \)  
C \( \frac{5 \cdot 3^{10} - 2}{2} \)  
D \( \frac{9 \cdot 3^{10} + 1}{2} \)

Sol.

\( S_n = 1 + 2 \cdot 3^1 + 3 \cdot 3^2 + 4 \cdot 3^3 + \ldots + 10 \cdot 3^9 \) 
\( 3S_n = 1 \cdot 3^1 + 2 \cdot 3^2 + 3 \cdot 3^3 + \ldots + 10 \cdot 3^{10} \)
9. Let \( \vec{r} \cdot \left( \hat{i} + 3 \hat{j} - \hat{k} \right) = 5 \) and \( \vec{r} \cdot \left( 2 \hat{i} - \hat{j} + \hat{k} \right) = 3 \), and the point \((2, 1, -2)\). Let the position vectors of the points \(X\) and \(Y\) be \( \hat{i} - 2\hat{j} + 4\hat{k} \) and \( 5\hat{i} - \hat{j} + 2\hat{k} \) respectively. Then the points

- A \( X \) and \( X + Y \) are on the same side of \( P \)
- B \( Y \) and \( Y - X \) are on the opposite sides of \( P \)
- C \( X \) and \( Y \) are on the opposite sides of \( P \)
- D \( X + Y \) and \( X - Y \) are on the same side of \( P \)

NTA Ans. (C)
Resonance Ans. (C)

10. A circle touches both the y-axis and the line \( x + y = 0 \). Then the locus of its center

- (A) \( y = \sqrt{2}x \)
- (B) \( x = \sqrt{2}y \)
- (C) \( y^2 - x^2 = 2xy \)
- (D) \( x^2 - y^2 = 2xy \)

NTA Ans. (D)
Resonance Ans. (D)

Sol.
Let centre of circle be \( C(h, k) \)
\[
\begin{align*}
\text{circle touches y-axis} & \Rightarrow \text{radius} = |h| \\
\text{circle touches x-axis} & \Rightarrow |h - k| = |h| \\
& \Rightarrow (h - k)^2 = 2h^2 \\
& \Rightarrow h^2 + k^2 - 2hk = 2h^2 \\
& \Rightarrow h^2 + 2h k - k^2 = 0 \\
\text{locus of } (h, k) & \Rightarrow x^2 + 2xy - y^2 = 0
\end{align*}
\]
11 Water is being filled at the rate of 1 cm³/sec in a right circular conical vessel (vertex downwards) of height 35 cm and diameter 14 cm. When the height of the water level is 10 cm, the rate (in cm²/sec) at which the wet conical surface area of the vessel increases is

(A) \( \frac{\sqrt{21}}{5} \)  
(B) \( \frac{\sqrt{26}}{5} \)  
(C) \( \frac{\sqrt{26}}{10} \)  
(D) \( \frac{\sqrt{26}}{10} \)

NTA Ans. (C)  
Reso Ans. (C)

12 Question:

If \( b_n = \int_0^\pi \frac{\cos^2 nx}{\sin x} \, dx, \, n \in \mathbb{N}, \) then

A \( b_3 - b_2, \ b_4 - b_3, \ b_5 - b_4 \) are in an A.P. with common difference -2

B \( \frac{1}{b_3 - b_2}, \ \frac{1}{b_4 - b_3}, \ \frac{1}{b_5 - b_4} \) are in an A.P. with common difference 2

C \( b_3 - b_2, \ b_4 - b_3, \ b_5 - b_4 \) are in a G.P.

D \( \frac{1}{b_3 - b_2}, \ \frac{1}{b_4 - b_3}, \ \frac{1}{b_5 - b_4} \) are in an A.P. with common difference -2

NTA Ans. (D)  
Reso Ans. (D)

Sol. \[
\begin{align*}
\frac{b_n - b_{n-1}}{n(n - 1)} &= \int_0^\pi \frac{\cos^2 nx - \cos^2 (n - 1)x}{\sin x} \, dx = \int_0^\pi \frac{\sin(2n - 1)x \sin(-x)}{\sin x} \\
&= -\int_0^\pi \sin(2n - 1)x \, dx = -\frac{1}{2n - 1} \left[ \cos(2n - 1)x \right]_0^\pi = \frac{1}{2n - 1} \\
\frac{1}{b_n - b_{n-1}} &= \frac{1}{n(n - 1)} = \frac{1}{(2n - 1)} \\
\frac{1}{b_3 - b_2} &= -5, \quad \frac{1}{b_4 - b_3} = -7, \quad \frac{1}{b_5 - b_4} = -9 \\
\text{common difference} &= -2
\end{align*}
\]
If \( y = y(x) \) is the solution of the differential equation \( 2x^2 \frac{dy}{dx} - 2xy + 3y^2 = 0 \) such that \( y(e) = \frac{e}{3} \), then \( y(1) \) is equal to

(A) \( \frac{1}{3} \) (B) \( \frac{2}{3} \) (C) \( \frac{3}{2} \) (D) 3

NTA Ans. (B)  
Reso Ans. (B)  
Sol.

\[
2x^2 \frac{dy}{dx} - 2xy + 3y^2 = 0
\]

\[
\frac{1}{y^2} \frac{dy}{dx} - \frac{1}{xy} + \frac{3}{2x^2} = 0
\]

Let \( \frac{1}{y} = t \)

Difference of

\[
- \frac{1}{y^2} \frac{dt}{dx} = \frac{dt}{dx}
\]

\[
- \frac{dt}{dx} - \frac{1}{x} t + \frac{3}{2x^2} = 0
\]

\[
\frac{dt}{dx} + \frac{1}{x} t = \frac{3}{2x^2}
\]

I.F. = \( e^{\int \frac{1}{x} dx} = x \)

x.t. = \( \int x \cdot \frac{3}{2x^2} dx \)

x.t. = \( \frac{3}{2} \sqrt{x} + c \)

\( x = \frac{3}{2} \sqrt{x} + c \)

\( x = e, y = e/3 \)

\( e = \frac{3}{2} \cdot 1 + c \)

\( c = \frac{3}{2} \)

\( x = \frac{3}{2} \sqrt{x} - \frac{3}{2} \)

\( x = 1 \)

\( y = \frac{3}{2} \)

\( y = 2/3 \)
If the angle made by the tangent at the point \((x_0, y_0)\) on the curve \(x = 12 \left( t + \sin t \cos t \right)\), 
\[ y = 12 \left( 1 + \sin t \right)^2, \quad 0 < t < \frac{\pi}{2}, \]
with the positive \(x\)-axis is \( \frac{\pi}{3} \), then \(y_0\) is equal to:

A \( 6 \left( 3 + 2\sqrt{2} \right) \)
B \( 3 \left( 7 + 4\sqrt{3} \right) \)
C \( 27 \)
D \( 48 \)

Question: The value of \(2 \sin(12^\circ) - \sin(72^\circ)\) is:

A \( \frac{\sqrt{5} \left( 1 - \sqrt{3} \right)}{4} \)
B \( \frac{1 - \sqrt{5}}{8} \)
C \( \frac{\sqrt{3} \left( 1 - \sqrt{5} \right)}{2} \)
D \( \frac{\sqrt{3} \left( 1 - \sqrt{5} \right)}{4} \)

Sol. 
\[ 2(\sin(72^\circ - 60)) - \sin 72^\circ \]
\[ = \left( \frac{\sin 72^\circ \cdot \left( 1 - \cos 72^\circ \cdot \frac{\sqrt{3}}{2} \right) - \sin 72^\circ}{2} \right) \]
\[ - \sqrt{3} \cos(72^\circ) \]
\[ - \sqrt{3} \sin(18^\circ) = -\sqrt{3} \left( \frac{\sqrt{5} - 1}{4} \right) = \sqrt{3} \left( 1 - \frac{\sqrt{5}}{4} \right) \]
A biased die is marked with numbers 2, 4, 8, 16, 32, 32 on its faces and the probability of getting a face with mark \( n \) is \( \frac{1}{n} \). If the die is thrown thrice, then the probability, that the sum of the numbers obtained is 48, is:

(A) \( \frac{7}{2^{11}} \)  
(B) \( \frac{7}{2^{12}} \)  
(C) \( \frac{3}{2^{10}} \)  
(D) \( \frac{13}{2^{12}} \)

NTA Ans. (D)  
Reso Ans. (D)  
Sol.

Given \( P(n) = \frac{1}{n} \)

Favourable cases (16, 16, 16), (32, 8, 8), (8, 32, 8), (8, 8, 32)

\[
\text{Prob} = \left( \frac{1}{16} \times \frac{1}{16} \times \frac{1}{16} \right) + 3 \times \left( \frac{1}{8} \times \frac{1}{8} \times \frac{1}{32} \right) = \frac{1}{2^{12}} + \frac{3}{2^{11}} = \frac{7}{2^{12}}
\]

The negation of the Boolean expression \(((\sim q) \land p) \Rightarrow ((\sim p) \lor q)\) is logically equivalent to:

(A) \( p \Rightarrow q \)  
(B) \( q \Rightarrow p \)  
(C) \( \sim (p \Rightarrow q) \)  
(D) \( \sim (q \Rightarrow p) \)

NTA Ans. (C)  
Reso Ans. (C)  
Sol.

\((p \land \sim q) \land (p \lor \sim q)\)
\[= (p \land \sim q)\]
\[= \sim (p \Rightarrow q)\]

If the line \( y = 4 + kx, k > 0 \), is the tangent to the parabola \( y = x - x^2 \) at the point \( P \) and \( V \) is the vertex of the parabola, then the slope of the line through \( P \) and \( V \) is:

(A) \( \frac{3}{2} \)  
(B) \( \frac{26}{9} \)  
(C) \( \frac{5}{2} \)  
(D) \( \frac{23}{6} \)

NTA Ans. (C)  
Reso Ans. (C)  
Sol.

\[y = kx + 4\]
\[y = x - x^2\]
\[kx + 4 = x - x^2\]
\[x^2 + (k - 1)x + 4 = 0\]
\[(k - 1)^2 - 4.4 = 0\]
\[k - 1 = \pm 4\]
if \( k = 5 \)

now put the value of \( k = 5 \)
\[5x + 4 = x - x^2\]
\[x^2 + 4x + 4 = 0\]
\[(x + 2)^2 = 0\]
\[x = -2\]
\[y = -6\]
if \( k = -3 \)
now put the value of $k = -3$ in equation (1)

$$-3x + 4 = x - x^2$$

$$x^2 - 4x + 4 = 0$$

$x = 2$ $y = -2$

then the point of $P$ is $(2, -2)$ and $(-2, -6)$

and vertex of parabola '$O$' = $y = \frac{1}{4} = -\frac{1}{4} + x - x^2$

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

point $P$ is $(2, -2)$

slope of $OP = \frac{-2 - \frac{1}{2}}{2 - \frac{1}{2}} = \frac{9}{2} \times \frac{2}{3} = \frac{3}{2}$

point $P$ is $(-2, -6)$ slope of $OP$

$$\frac{-6 - \frac{1}{2}}{-2 - \frac{1}{2}} = \frac{5}{2}$$

The value of $\tan^{-1}\left( \frac{\cos\left(\frac{15\pi}{4}\right) - 1}{\sin\left(\frac{\pi}{4}\right)} \right)$ is equal to:

Question:

A $\frac{\pi}{4}$

B $\frac{\pi}{8}$

C $\frac{5\pi}{12}$

D $\frac{4\pi}{9}$

NTA Ans. (B)
Reso Ans. (B)

Sol.

$$\tan^{-1}\left( \frac{1}{\sqrt{2}} - 1 \right) = \tan^{-1}\left(1 - \sqrt{2}\right) = -\tan^{-1}\left(\sqrt{2} - 1\right) = -\frac{\pi}{8}$$

The line $y = x + 1$ meets the ellipse $\frac{x^2}{4} + \frac{y^2}{2} = 1$ at two points $P$ and $Q$. If $r$ is the radius of the circle with $PQ$ as diameter then $(3r)^2$ is equal to:
21

Let \( A = \begin{pmatrix} 2 & -2 \\ 1 & -1 \end{pmatrix} \) and \( B = \begin{pmatrix} -1 & 2 \\ -1 & 2 \end{pmatrix} \). Then the number of elements in the set \( \{(n, m) : n, m \in \{1, 2, \ldots, 10\} \text{ and } nA^n + mB^m = I\} \) is ________.

NTA Ans. 1
Reso Ans. 1

22

Let \( f(x) = \left\lfloor 2x^2 + 1 \right\rfloor \) and \( g(x) = \begin{cases} 2x - 3, & x < 0 \\ 2x + 3, & x \geq 0 \end{cases} \), where \( \lfloor r \rfloor \) is the greatest integer \( \leq r \). Then, in the open interval \((-1, 1)\), the number of points where \( f \circ g \) is discontinuous is equal to __________.

NTA Ans. 62
Reso Ans. 62
The value of $b > 3$ for which \( 12 \int_3^b \frac{1}{(x^2-1)(x^2-4)} \, dx = \log \left( \frac{49}{40} \right) \), is equal to __________.

NTA Ans. 6
Reso Ans. 6

24. If the sum of the co-efficients of all the positive even powers of $x$ in the binomial expansion of \( (2x^3 + \frac{3}{x})^{10} \) is $5^{10} - \beta \cdot 3^9$, then $\beta$ is equal to __________.

NTA Ans. 83
Reso Ans. 83

25. If the mean deviation about the mean of the numbers 1, 2, 3, ..., $n$, where $n$ is odd, is \( \frac{5(n+1)}{n} \), then $n$ is equal to __________.

NTA Ans. 21
Reso Ans. 21
Sol.

\[
\bar{x} = \frac{1 + 2 + 3 + \ldots + n}{n} = \frac{n(n+1)}{2n} = \frac{n+1}{2} \quad \text{(which is middle term)}
\]

M.D. = \( \frac{\sum |x_i - \bar{x}|}{n} \)

\[
= \frac{2 \left( 1 + 2 + 3 + \ldots + \frac{(n-1)}{2} \right)}{n} = \frac{5(n+1)}{n}
\]

\[
= \frac{\left( \frac{(n-1)(n-1)}{2} \right) + 1}{2} \cdot \frac{2}{n} = \frac{5(n+1)}{n}
\]

\[
\Rightarrow \frac{(n-1)(n+1)}{4n} = \frac{5(n+1)}{n}
\]

\[
n = 21
\]

26. Let \( \vec{b} = \hat{i} + \hat{j} + \lambda \hat{k}, \lambda \in \mathbb{R} \). If \( \vec{a} \) is a vector such that \( \vec{a} \times \vec{b} = 13 \hat{i} - \hat{j} - 4 \hat{k} \) and \( \vec{a} \cdot \vec{b} + 21 = 0 \), then \( (\vec{b} - \vec{a}) \cdot (\hat{k} - \hat{j}) + (\vec{b} + \vec{a}) \cdot (\hat{i} - \hat{k}) \) is equal to __________.

NTA Ans. 14
27. The total number of three-digit numbers, with one digit repeated exactly two times, is ________.

NTA Ans. 243
Reso Ans. 243

28. Let \( f(x) = |(x-1)(x^2-2x-3)| + x - 3 \), \( x \in \mathbb{R} \). If \( m \) and \( M \) are respectively the number of points of local minimum and local maximum of \( f \) in the interval \((0, 4)\), then \( m + M \) is equal to _________.

NTA Ans. 3
Reso Ans. 3
Sol.

29. Let the eccentricity of the hyperbola \( \frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 \) be \( \frac{5}{4} \). If the equation of the normal at the point \( \left( \frac{8}{\sqrt{5}}, \frac{12}{5} \right) \) on the hyperbola is \( 8\sqrt{5}x + \beta y = \lambda \), then \( \lambda - \beta \) is equal to _________.

NTA Ans. 85
Reso Ans. 85

30. Let \( l_1 \) be the line in \( xy \)-plane with \( x \) and \( y \) intercepts \( \frac{1}{8} \) and \( \frac{1}{4\sqrt{2}} \) respectively, and \( l_2 \) be the line in \( zx \)-plane with \( x \) and \( z \) intercepts \( -\frac{1}{8} \) and \( -\frac{1}{6\sqrt{3}} \) respectively. If \( d \) is the shortest distance between the line \( l_1 \) and \( l_2 \), then \( d^{-2} \) is equal to _________.

NTA Ans. 51
Reso Ans. 51
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The Strong Faculty Team at Resonance Kota to deliver this successful Teaching Methodology.

Photo Taken on 20th June 2022 | Some Faculty Members were not present in the Photo Session.

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1. The minimum energy that must be possessed by photons in order to produce the photoelectric effect with platinum metal is:

[Given: The threshold frequency of platinum is $1.3 \times 10^{15}$ s$^{-1}$ and $h = 6.6 \times 10^{-34}$ J s$^{-1}$]

- A $3.21 \times 10^{-14}$ J
- B $6.24 \times 10^{-16}$ J
- C $8.58 \times 10^{-19}$ J
- D $9.76 \times 10^{-20}$ J

**Ans (C)**

**Sol.**

$$E = E_0 + KE$$

For minimum energy:

$$E = E_0 = \left( \frac{hc}{\lambda} \right) = hv$$

$$= 6.6 \times 10^{-34} \times 1.3 \times 10^{15}$$

$$= 8.58 \times 10^{-19} \text{ J}$$

2. At 25°C and 1 atm pressure, the enthalpy of combustion of benzene (l) and acetylene (g) are $-3268$ kJ mol$^{-1}$ and $-1300$ kJ mol$^{-1}$, respectively. The change in enthalpy for the reaction $3 \text{C}_2\text{H}_2(g) \rightarrow \text{C}_6\text{H}_6(l)$ is

- A $+324$ kJ mol$^{-1}$
- B $+632$ kJ mol$^{-1}$
- C $-632$ kJ mol$^{-1}$
- D $-732$ kJ mol$^{-1}$

**Ans (C)**

**Sol.**

$$\Delta H_r = (\Delta H_c)_\text{reactant} - (\Delta H_c)_\text{product}$$

$$= 3\left[ \Delta H_c(\text{C}_2\text{H}_2, g) \right] - \left[ \Delta H_c(\text{C}_6\text{H}_6, l) \right]$$

$$= 3 \times (-1300) - (-3268)$$

$$= -3900 + 3268 = -632 \text{ kJ/mole}$$

This solution was download from Resonance JEE (MAIN) 2022 Solution portal
3. Solute A associates in water. When 0.7 g of solute A is dissolved in 42.0 g of water, it depresses the freezing point by 0.2°C. The percentage association of solute A in water, is:

[Given: Molar mass of A = 93 g mol⁻¹. Molal depression constant of water is 1.86 K kg mol⁻¹.]

A 50%  
B 60%  
C 70%  
D 80%

Ans (D)

Sol. \[ \Delta T_f = i[K_f \times m] \]
\[ 2.0 = i[1.86 \times \frac{7 \times 1000}{93 \times 42}] \]
\[ i = 0.6 \]
\[ i = 1 + \frac{1}{n} - 1 \beta \]
\[ 0.6 = 1 + \frac{1}{2} - 1 \beta \]
\[ \beta = 0.8 \]
\[ \%\beta = 80 \%

4. The K_{sp} for bismuth sulphide (Bi₂S₃) is \(1.08 \times 10^{-73}\). The solubility of Bi₂S₃ in mol L⁻¹ at 298 K is

A \(1.0 \times 10^{-15}\)  
B \(2.7 \times 10^{-12}\)  
C \(3.2 \times 10^{-10}\)  
D \(4.2 \times 10^{-8}\)

Ans (A)

Sol. \[ Bi_2S_3(s) \rightleftharpoons 2Bi^{3+} + 3S^{2-} \]
\[ 2S \quad 3S \]
\[ K_{sp}(Bi_2S_3) = (2S)^2 \times (3S)^3 \]
\[ = (2)^2 \times (3)^3 \times (S)^5 \]
\[ 1.08 \times 10^{-73} = 4 \times 27(S)^5 \]
5. Match List I with List II.

<table>
<thead>
<tr>
<th>List I</th>
<th>List II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Zymase</td>
<td>I. Stomach</td>
</tr>
<tr>
<td>B. Diastase</td>
<td>II. Yeast</td>
</tr>
<tr>
<td>C. Urease</td>
<td>III. Malt</td>
</tr>
<tr>
<td>D. Pepsin</td>
<td>IV. Soyabean</td>
</tr>
</tbody>
</table>

Choose the correct answer from the options given below:

A. A-II, B-III, C-I, D-IV
B. A-II, B-III, C-IV, D-I
C. A-III, B-II, C-IV, D-I
D. A-III, B-II, C-I, D-IV

Ans: (B)

6. The correct order of electron gain enthalpies of Cl, F, Te and Po is

A. $1.0 \times 10^{-15}$
B. $2.7 \times 10^{-12}$
C. $3.2 \times 10^{-10}$
D. $4.2 \times 10^{-8}$

Ans: (B)

Sol. | Element | Electron Gain Enthalpies (kJ mol$^{-1}$) |
---|---------|----------------------------------------|
F  | –328    |
Cl | –349    |
Te | –190    |
Po | –174    |
7. Given below are two statements.

Statement I: During electrolytic refining, blister copper deposits precious metals.
Statement II: In the process of obtaining pure copper by electrolysis method, copper blister is used to make the anode.

In the light of the above statements, choose the correct answer from the options given below.

A. Both Statement I and Statement II are true.
B. Both Statement I and Statement II are false.
C. Statement I is true but Statement II is false.
D. Statement I is false but Statement II is true.

Ans (A)

Sol. Impure Cu obtained from ores is converted to pure Cu in an electrolyte cell that the impure copper as the anode and pure copper as the cathode. The electrolyte is an aqueous solution of CuSO₄. At the impure Cu anode, Cu is oxidized along with the more easily oxidized metallic impurities such as Zn and Fe. The less easily oxidized impurities such as Ag, Au, and Pt fall to the bottom of the cell as anode mud, which is reprocessed to recover the precious metals. At the pure Cu cathode, Cu²⁺ ions get reduced to pure copper metal.

Anode (oxidation): \( \text{M(s)} \rightarrow \text{M}^{2+} \text{(aq)} + 2\text{e}^- \) (M = Cu, Zn, Fe)

Cathode (reduction): \( \text{Cu}^{2+} \text{(aq)} + 2\text{e}^- \rightarrow \text{Cu(s)} \)

Thus, the net cell reaction simply involves transfer of Cu metal from the impure anode to the pure cathode, Cu obtained by this process is 99.95% pure.

8. Given below are two statements one is labelled as **Assertion A** and the other is labelled as **Reason R**:

**Assertion A**: The amphoteric nature of water is explained by using Lewis acid/base concept.

**Reason R**: Water acts as an acid with \( \text{NH}_3 \) and as a base with \( \text{H}_2\text{S} \).

In the light of the above statements choose the correct answer from the options given below:

A. Both Assertion A and Reason R are true.
B. Both Assertion A and Reason R are false.
C. Assertion A is true but Reason R is false.
D. Assertion A is false but Reason R is true.
A Both A and R are true and R is the correct explanation of A.
B Both A and R are true but R is NOT the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

Ans: (D)

Sol: According to Lewis concept water act as Base.

9 The correct order of reduction potentials of the following pairs is
A. Cl₂/Cl⁻
B. I₂/I⁻
C. Ag⁺/Ag
D. Na⁺/Na
E. Li⁺/Li

Choose the correct answer from the options given below.

A. A > C > B > D > E
B. A > B > C > D > E
C. A > C > B > E > D
D. A > B > C > E > D

Ans: (A)

Sol: 
\[ E^{\circ}_{Cl_2/Cl^-} = 1.36 \text{V} \]
\[ E^{\circ}_{I_2/I^-} = +0.54 \text{V} \]
\[ E^{\circ}_{Ag^+/Ag} = 0.80 \text{V} \]
\[ E^{\circ}_{Na^+/Na} = -2.71 \text{V} \]
\[ E^{\circ}_{Li^+/Li} = -3.05 \text{V} \]

10 The number of bridged oxygen atoms present in compound B formed from the following reactions is

\[ \text{Pb(NO}_3\text{)}_2 \xrightarrow{673 K} \text{A + PbO} + \text{O}_2 \]

A. Dimerise
B. 

A. 0
11. The metal ion (in gaseous state) with lowest spin-only magnetic moment value is

A. V$^{2+}$  
B. Ni$^{2+}$  
C. Cr$^{2+}$  
D. Fe$^{2+}$

Ans (B)  

Sol.  

<table>
<thead>
<tr>
<th>Ion</th>
<th>Electronic configuration</th>
<th>No. of unpaired electron</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Cr$^{2+}$</td>
<td>3d$^4$</td>
<td>4</td>
</tr>
<tr>
<td>(2) V$^{2+}$</td>
<td>3d$^3$</td>
<td>3</td>
</tr>
<tr>
<td>(3) Fe$^{2+}$</td>
<td>3d$^6$</td>
<td>4</td>
</tr>
<tr>
<td>(4) Ni$^{2+}$</td>
<td>3d$^8$</td>
<td>2</td>
</tr>
</tbody>
</table>

Less is no. of unpaired electron less is magnetic moment (spin only).

12. Given below are two statements: one is labelled as **Assertion A** and the other is labelled as **Reason R**.

**Assertion A:** Polluted water may have a value of BOD of the order of 17 ppm.  
**Reason R:** BOD is a measure of oxygen required to oxidize both the biodegradable and non-biodegradable organic material in water.

In the light of the above statements, choose the most appropriate answer from the options given below.
A Both A and R are correct and R is the correct explanation of A.
B Both A and R are correct but R is NOT the correct explanation of A.
C A is correct but R is not correct.
D A is not correct but R is correct.

Ans (C)

Sol. The amount of BOD in the water is a measure of the amount of organic material in the water, in terms of how much oxygen will be required to break it down biologically. Clean water would have BOD value of less than 5 ppm whereas highly polluted water could have a BOD value of 17 ppm or more.

13 Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: A mixture contains benzoic acid and napthlalene. The pure benzoic acid can be separated out by the use of benzene.
Reason R: Benzoic acid is soluble in hot water.

In the light of the above statements, choose the most appropriate answer from the options given below.
A Both A and R are true and R is the correct explanation of A.
B Both A and R are true but R is NOT the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

Ans (D)

Sol. Aromatic acids are insoluble in water but soluble in aqueous NaHCO$_3$ solution or NaOH solution, due to salt formation.

14 During halogen test, sodium fusion extract is boiled with concentrated HNO$_3$ to
A remove unreacted sodium
B decompose cyanide or sulphide of sodium
C extract halogen from organic compound
D maintain the pH of extract.

Ans (B)
Sol. The sodium fusion extract is first boiled with concentrated nitric acid to decompose cyanide or sulphide of sodium formed during Lassaigne’s test. These ions would otherwise interfere with silver nitrate test for halogens.

15. Amongst the following, the major product of the given chemical reaction is

\[
\text{Br}_2 \xrightarrow{\text{CH}_3\text{OH}} \text{Major Product}
\]

**Ans.** (A)

Sol. The reaction proceed via cyclic bromonium ion with anti addition mechanism.

\[\text{Br}^+ \rightarrow \text{Br}^- \]

16. In the given reaction

\[
2 \text{A} \xrightarrow{\text{(i) 2 Mg, THF}} \text{(ii) Methyl benzoate}} \xrightarrow{\text{(iii) H}_2\text{O} / \text{H}^+} \]

‘A’ can be
17. Which of the following conditions or reaction sequence will NOT give acetophenone as the major product?

A

\[ \text{C}_6\text{H}_5\text{CO} + \text{CH}_3\text{MgBr} \rightarrow \text{PhCOCH}_3 \]

B

\[ \text{H}_3\text{C} + \text{C}_6\text{H}_5\text{MgBr} \rightarrow \text{PhC(CH}_3)_2\text{OH} \]

C

\[ \text{H}_3\text{C} + \text{C}_6\text{H}_5\text{MgBr} \rightarrow \text{PhC(CH}_3)_2\text{OH} \]

D

\[ \text{H}_3\text{C} + \text{C}_6\text{H}_5\text{MgBr} + \text{CdCl}_2 \]

Answer: (B)

Solution:

\[ \text{Ph} - \text{COO} + \text{CH}_3\text{MgBr} \rightarrow \text{PhCOCH}_3 \]

18. The major product formed in the following reaction, is
19. Which of the following ketone will NOT give enamine on treatment with secondary amines? [where t-Bu is \(-\text{C}(\text{CH}_3)_3\)]

A

\[
\text{A} \quad \begin{array}{c}
\text{C}_2\text{H}_5 \\
\text{C}_2\text{H}_5
\end{array}
\]

B

\[
\text{B} \quad \begin{array}{c}
\text{C}_2\text{H}_5 \\
\text{CH}_3
\end{array}
\]

C

\[
\text{C} \quad \begin{array}{c}
t-\text{Bu} \\
t-\text{Bu}
\end{array}
\]

D

\[
\text{D} \quad \begin{array}{c}
\text{O}
\end{array}
\]

Ans (C)
Sol. \( t-\text{Bu} - \text{C} - t-\text{Bu} \) neither has \( \alpha \) H, as well as sterically crowded for any nucleophilic attack by 2º amine.

20. An antiseptic dettol is a mixture of two compounds ‘A’ and ‘B’ where A has 6\( \pi \) electrons and B has 2\( \pi \) electrons. What is ‘B’?
   
   A. Bithionol
   B. Terpineol
   C. Chloroxylenol
   D. Chloramphenicol

Ans (B)

Sol.

Chloroxylenol and Terpineol

21. A protein ‘A’ contains 0.30% of glycine (molecular weight 75). The minimum molar mass of the protein ‘A’ is \( \frac{75 \times 1}{GMM} \times 100 = 0.3 \) [nearest integer]

Ans (25)

Sol.

\[
\% \text{ of glycine} = \left[ \frac{75 \times 1}{GMM} \right] \times 100 = 0.3
\]

\[
GMM = \left[ \frac{75 \times 100}{0.3} \right] = 25 \times 10^3
\]

22. A rigid nitrogen tank stored inside a laboratory has a pressure of 30 atm at 06:00 am when the temperature is 27 °C. At 03:00 pm, when the temperature is 45°C, the pressure in the tank will be \( \frac{p_1}{p_2} = \frac{T_1}{T_2} \) atm. [nearest integer]

Ans (32)

Sol. At constant volume and mole

\[
\frac{p_1}{T_1} = \frac{p_2}{T_2}
\]

\[
\frac{30}{318} = \frac{p_2}{318} = p_2
\]
23. Amongst BeF₂, BF₃, H₂O, NH₃, CCl₄ and HCl, the number of molecules with non-zero net dipole moment is _________.

Ans. (3)

Sol. Polar molecules = H₂O, NH₃, HCl
Non-polar molecules = BeF₂, BF₃, CCl₄

24. At 345 K, the half life for the decomposition of a sample of a gaseous compound initially at 55.5 kPa was 340 s. When the pressure was 27.8 kPa, the half life was found to be 170 s. The order of the reaction is _________. [integer answer]

Ans. (0)

Sol. \( \frac{(t_{1/2})_1}{(t_{1/2})_2} = \left( \frac{P_1}{P_2} \right)^{1-n} \) \( \Rightarrow \frac{340}{170} = \left( \frac{55.5}{27.8} \right)^{1-n} \)

\( 2^1 = (2)^{1-n} \)

\( 1 = 1 - n \Rightarrow n = 0 \)

25. A solution of Fe₂(SO₄)₃ is electrolyzed for ‘x’ min with a current of 1.5 A to deposit 0.3482 g of Fe. The value of x is _________. [nearest integer]

Given: 1 F = 96500 C mol⁻¹

Atomic mass of Fe = 56 g mol⁻¹

Ans. (20)

Sol. Fe₂(SO₄)₃ \( \rightarrow \) 2Fe

\( w = \frac{E}{96500} it \)

\( 0.3482 = \left( \frac{56}{3 \times 96500} \right) \times 1.5 \times t \)

\( t = 1200 \text{ sec} = 20 \text{ min} \)
26. Consider the following reactions:

$$\text{PCl}_3 + \text{H}_2\text{O} \rightarrow \text{A} + \text{HCl}$$

$$\text{A} + \text{H}_2\text{O} \rightarrow \text{B} + \text{HCl}$$

The number of ionisable protons present in the product B is ________.

Ans (2)

Sol.  

PCl$_3$ + H$_2$O $\rightarrow$ POCl$_3$ + 2HCl  

POCl$_3$ + 3H$_2$O $\rightarrow$ H$_3$PO$_4$ + 3HCl  

No. of ionisable hydrogen = 3

27. Amongst FeCl$_3$·3H$_2$O, K$_3$[Fe(CN)$_6$] and [Co(NH$_3$)$_6$]Cl$_3$, the spin-only magnetic moment value of the inner-orbital complex that absorbs light at shortest wavelength is ________ B.M. [nearest integer]

Ans (2)

Sol.  

<table>
<thead>
<tr>
<th>Complex</th>
<th>EC</th>
<th>Hybridisation</th>
<th>No. of unpaired e$^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) FeCl$_3$·3H$_2$O</td>
<td>Fe$^{3+}$ = 3d$^5$</td>
<td>sp$^3$d$^2$</td>
<td>5</td>
</tr>
<tr>
<td>(ii) K$_3$[Fe(CN)$_6$]</td>
<td>Fe$^{3+}$ = 3d$^5$</td>
<td>d$^2$sp$^3$</td>
<td>1</td>
</tr>
<tr>
<td>(iii) [Co(NH$_3$)$_6$]Cl$_3$</td>
<td>Co$^{3+}$ = 3d$^6$</td>
<td>d$^2$sp$^3$</td>
<td>0</td>
</tr>
</tbody>
</table>

CN$^-$ is strong ligand than NH$_3$ so splitting in K$_3$[Fe(CN)$_6$] is higher and it absorb light of shortest wavelength

$$\mu (\text{spin only}) = \sqrt{n(n + 2)} = \sqrt{3} = 1.73 \text{ BM} \approx 2 \text{ BM}$$

28. The Novolac polymer has mass of 963 g. The number of monomer units present in it are

Ans (9)

Sol.  

Monomer of NOVOLAC is with molar mass 124.
Let there is $n$ no. of monomer unit, therefore in Novalac formation $(n-1)$ unit of water is removed.

or \[n \times 124 = 963 + (n-1) \times 18\]

\[n = 9.\]

29. How many of the given compounds will give a positive Biuret test? _________?
Glycine, Glycylalanine, Tripeptide, Biuret

Ans (2)

Sol. Tripeptide, only species with peptide bond gives biureate test.

30. The neutralization occurs when 10 mL of 0.1M acid ‘A’ is allowed to react with 30 mL of 0.05 M base $M(OH)_2$. The basicity of the acid ‘A’ is _________.
[M is a metal]

Ans (3)

Sol. Let basicity of acid is $x$

\[A + M(OH)_2 \rightarrow \text{Salt} + \text{Water}\]

At complete neutralization.

Milli eq. of acid = Milli eq. of base

\[n[0.1 \times 10] = 2[0.05 \times 30]\]

\[n = 3\]
JEE (Main)

PAPER-1 (B.E./B. TECH.)

2022

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 25 June, 2022 (SHIFT-2) | TIME: (3.00 p.m. to 6.00 p.m)
Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS
PART : PHYSICS

1. Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.

**Assertion A:** Two identical balls A and B thrown with same velocity ‘u’ at two different angles with horizontal attained the same range \( R \). If \( A \) and \( B \) reached the maximum height \( h_1 \) and \( h_2 \) respectively, then \( R = 4\sqrt{h_1h_2} \)

**Reason R:** Product of said heights.

\[ h_1h_2 = \left( \frac{u^2 \sin^2 \theta}{2g} \right) \cdot \left( \frac{u^2 \cos^2 \theta}{2g} \right) \]

**Question:** Choose the correct answer:

A. Both A and R are true and R is the correct explanation of A.
B. Both A and R are true but R is NOT the correct explanation of A.
C. A is true but R is false.
D. A is false but R is true.

**Ans. A**

**Sol.**

\[ R_1 = \frac{u^2 \sin 2\theta_1}{g} \quad R_2 = \frac{u^2 \sin 2\theta_2}{g} \]

\[ H_1 = \frac{u^2 \sin^2 \theta_1}{2g} \quad H_2 = \frac{u^2 \cos^2 \theta_1}{2g} \]

\[ H_1H_2 = \frac{u^4 \sin^2 \theta \cos^2 \theta}{4g^2} \]

2. Two buses \( P \) and \( Q \) start from a point at the same time and move in a straight line and their positions are represented by \( X_P (t) = at + \beta t^2 \) and \( X_Q (t) = ft - t^2 \). At what time, both the buses have same velocity?

A. \( \frac{a-f}{1+\beta} \)
B. \( \frac{a+f}{2(\beta-1)} \)
C. \( \frac{a+f}{2(1+\beta)} \)
D. \( \frac{f-a}{2(1+\beta)} \)

**Ans. D**
3. A disc with a flat small bottom beaker placed on it at a distance $R$ from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity $\omega$. The coefficient of static friction between the bottom of the beaker and the surface of the disc is $\mu$. The beaker will revolve with the disc if:

A. $R \leq \frac{\mu g}{2\omega^2}$

B. $R \leq \frac{\mu g}{2\omega}$

C. $R \geq \frac{\mu g}{2\omega}$

D. $R \geq \frac{\mu g}{2\omega^2}$

Ans. B

Sol. From FBD

\[ \omega \quad f_r \quad m \omega^2 \quad N = mg \]

For circular motion

\[ f = m \omega^2 r \]

\[ \mu N \geq m \omega^2 r \]

\[ \mu mg \geq m \omega^2 r \]

\[ r \leq \frac{\mu g}{2\omega^2} \]
A solid metallic cube having total surface area 24 m\(^2\) is uniformly heated. If its temperature is increased by 10°C, calculate the increase in volume of the cube.

\(\text{Given } \alpha = 5.0 \times 10^{-4} \text{°C}^{-1}\).

\[
\begin{align*}
\text{A} & : 2.4 \times 10^6 \text{ cm}^3 \\
\text{B} & : 1.2 \times 10^5 \text{ cm}^3 \\
\text{C} & : 6.0 \times 10^4 \text{ cm}^3 \\
\text{D} & : 4.8 \times 10^5 \text{ cm}^3
\end{align*}
\]

**Ans.** B

**Sol.**

Given Total surface area \(6l^2 = 24 \Rightarrow l = \sqrt{\frac{24}{6}} = 2 \text{ m}\)

\[\Delta v = \Delta \theta \gamma (3 \alpha) \Delta \theta = 3 \times 2 \times 5 \times 10^{-4} \times 10 = 12 \times 10^{-2} \text{ m}^3 = 1.2 \times 10^5 \text{ cm}^3\]

A copper block of mass 5.0 kg is heated to a temperature of 500°C and is placed on a large ice block. What is the maximum amount of ice that can melt?

[Specific heat of copper : 0.39 J g\(^{-1}\) °C\(^{-1}\) and latent heat of fusion of water : 335 J g\(^{-1}\) ]

\[
\begin{align*}
\text{A} & : 1.5 \text{ kg} \\
\text{B} & : 5.8 \text{ kg} \\
\text{C} & : 2.9 \text{ kg} \\
\text{D} & : 3.8 \text{ kg}
\end{align*}
\]

**Ans.** C

**Sol.** Heat given by block = heat received by ice.

\[
\text{M.S. (T} - \text{O)} = \text{M}_{\text{Ice}} \gamma \text{L}
\]

\[
\therefore \quad \text{M}_{\text{Ice}} = \frac{\text{M}_{\text{ST}} \gamma \text{L}}{\text{M}_{\text{ST}}} = \frac{5 \times 500 \times 0.39}{335} = 2.9 \text{ kg}
\]
The ratio of specific heats \( \left( \frac{C_p}{C_v} \right) \) in terms of degree of freedom \( (f) \) is given by:

- A \( \left( 1 + \frac{f}{3} \right) \)
- B \( \left( 1 + \frac{f}{2} \right) \)
- C \( \left( 1 + \frac{f}{4} \right) \)
- D \( \left( 1 + \frac{1}{f} \right) \)

Ans. B

For a particle in uniform circular motion, the acceleration \( \vec{a} \) at any point \( P(R, \theta) \) on the circular path of radius \( R \) is \( (\text{when } \theta \text{ is measured from the positive } x\text{-axis and } v \text{ is uniform speed}) \):

- A \( \frac{v^2}{R} \sin \theta \hat{i} + \frac{v^2}{R} \cos \theta \hat{j} \)
- B \( \frac{v^2}{R} \cos \theta \hat{i} + \frac{v^2}{R} \sin \theta \hat{j} \)
- C \( -\frac{v^2}{R} \cos \theta \hat{i} - \frac{v^2}{R} \sin \theta \hat{j} \)
- D \( \frac{v^2}{R} \hat{i} + \frac{v^2}{R} \hat{j} \)

Ans. C

Sol.

\[ a = \frac{v^2}{R} \]
Two metallic plates form a parallel plate capacitor. The distance between the plate is ‘d’. A metal sheet of thickness \( \frac{d}{2} \) and of area equal to area of each plate is introduced between the plates. What will be the ratio of the new capacitance to the original capacitance of the capacitor?

A 2:1  
B 1:2  
C 1:4  
D 4:1

**Ans. A**

**Sol.**

Initial

\[
\begin{align*}
C &= \frac{\varepsilon_0 A}{d} \\
C' &= 2 \frac{\varepsilon_0 A}{d - \frac{d}{2}} = \frac{2 \varepsilon_0 A}{d}
\end{align*}
\]

\[
\frac{C'}{C} = 2
\]

Final

\[
\begin{align*}
C' &= 2 \frac{\varepsilon_0 A}{d - \frac{d}{2}} = \frac{2 \varepsilon_0 A}{d}
\end{align*}
\]

\[
\frac{C'}{C} = 2
\]
Two cells of same emf but different internal resistances \( r_1 \) and \( r_2 \) are connected in series with a resistance \( R \). The value of resistance \( R \), for which the potential difference across second cell is zero, is:

A \( r_2 - r_1 \)  
B \( r_1 - r_2 \)  
C \( r_1 \)  
D \( r_2 \)

Ans. A

Sol.

\[
\begin{align*}
R \\
e & \quad \text{e} \quad \text{e} \\
r_1 & \quad r_2 \\
i & = \frac{2\epsilon}{r_1 + r_2 + R} \\
\Delta V_2 & = \epsilon - \epsilon_2 = 0 \\
\epsilon & = \frac{2\epsilon}{r + r_2 + R} \times r_2 \\
R & = r_2 - r_1
\end{align*}
\]

10. Given below are two statements:

Statement – I : Susceptibilities of paramagnetic and ferromagnetic substances increase with decrease in temperature.

Statement – II : Diamagnetism is a result of orbital motions of electrons developing magnetic moments opposite to the applied magnetic field.

Choose the correct answer from the options given below:

A Both Statement – I and Statement – II are true.

B Both Statement – I and Statement – II are false.

C Statement – I is true but Statement – II is false.

D Statement – I is false but Statement – II is true.

Ans. A
11. A long solenoid carrying a current produces a magnetic field $B$ along its axis. If the current is doubled and the number of turns per cm is halved, the new value of magnetic field will be equal to

A $B$
B $2B$
C $4B$
D $\frac{B}{2}$

Ans. A

Sol.

\[ B = \mu_0 \left( \frac{N}{\ell} \right) I \]  \hspace{1cm} \text{.........(i)}

\[ N' = \frac{N}{2} \]

\[ I' = 2I \]

\[ B' = \mu_0 \left( \frac{N/2}{\ell} \right) 2I; \quad B' = B. \]

12. A sinusoidal voltage $V(t) = 210 \sin 3000t$ volt is applied to a series LCR circuit in which $L = 10 \text{ mH}$, $C = 25 \mu\text{F}$ and $R = 100 \Omega$. The phase difference ($\Phi$) between the applied voltage and resultant current will be:

A $\tan^{-1}(0.17)$
B $\tan^{-1}(9.46)$
C $\tan^{-1}(0.30)$
D $\tan^{-1}(13.33)$

Ans. A

Sol.

\[ X_C = \frac{1}{\omega C} = \frac{1}{3000 \times 25 \times 10^{-6}} = \frac{40}{3} \Omega \]

\[ X_L = \omega L = 3000 \times 10 \times 10^{-3} = 30 \Omega \]

\[ X = X_L - X_C = 30 - \frac{40}{3} = \frac{50}{3} \Omega \]

\[ \tan \phi = \frac{X}{R} = \frac{50/3}{100} = \frac{1}{6} \]

\[ \tan \phi = \frac{1}{6} = 0.17 \]
13. The electromagnetic waves travel in a medium at a speed of $2.0 \times 10^8 \text{ m/s}$. The relative permeability of the medium is 1.0. The relative permittivity of the medium will be:

A. 2.25  
B. 4.25  
C. 6.25  
D. 8.25

Ans. A  
Sol.  
$$\frac{1}{\sqrt{\mu r}} = 2 \times 10^8 = \frac{1}{\sqrt{\mu r_0 \epsilon_0}} = \frac{3 \times 10^8}{\sqrt{\epsilon r}}$$  
$$\epsilon r = \frac{9}{4}$$

14. The interference pattern is obtained with two coherent light sources of intensity ratio 4:1. And the ratio \( \frac{I_{\text{max}} + I_{\text{min}}}{I_{\text{max}} - I_{\text{min}}} \) is \( \frac{5}{x} \). Then, the value of \( x \) will be equal to:

A. 3  
B. 4  
C. 2  
D. 1

Ans. B  
Sol.  
$$\frac{I_1}{I_2} = \frac{4}{1} \Rightarrow \frac{A_1}{A_2} = \frac{2}{1}$$  
\( (A)_{\text{max}} = \frac{2 + 1}{2 - 1} = \frac{3}{1} \)  
\( (I)_{\text{max}} = \left( \frac{3}{1} \right)^2 = \frac{9}{1} \)  
\( (I)_{\text{min}} = \left( \frac{2}{1} \right)^2 = \frac{4}{1} \)  
\( (I)_{\text{max}} + (I)_{\text{min}} = \frac{9 + 1}{9 - 1} = \frac{10}{8} = \frac{5}{4} \)  
\( (I)_{\text{max}} - (I)_{\text{min}} = \frac{9 - 1}{9 - 1} = \frac{8}{4} \)  
So, \( x = 4 \)
15. A light whose electric field vectors are completely removed by using a good polaroid, allowed to incident on the surface of the prism at Brewster’s angle. Choose the most suitable option for the phenomenon related to the prism.

A. Reflected and refracted rays will be perpendicular to each other.
B. Wave will propagate along the surface of prism.
C. No refraction, and there will be total reflection of light.
D. No reflection. and there will be total transmission of light.

Ans. D

16. A proton, a neutron, an electron and an α-particle have same energy. If \( \lambda_p, \lambda_m, \lambda_e \) and \( \lambda_\alpha \) are the de Broglie’s wavelengths of proton, neutron, electron and α particle respectively, then choose the correct relation from the following:

A. \( \lambda_p = \lambda_n > \lambda_e > \lambda_\alpha \)
B. \( \lambda_\alpha < \lambda_n < \lambda_p < \lambda_e \)
C. \( \lambda_e < \lambda_p = \lambda_n > \lambda_\alpha \)
D. \( \lambda_e = \lambda_p = \lambda_n = \lambda_\alpha \)

Ans. B

Sol.
\[ \lambda = \frac{h}{\sqrt{2mE}} \]
\[ \lambda \propto \frac{1}{\sqrt{m}} \]

Let mass of electron = \( m_e \)
Let mass of Proton = \( m \)
Let mass of Neutron = 2m
Let mass of α particle = 4m
and \( m_e < m \)
Which of the following figure represents the variation of $\ln \left( \frac{R}{R_0} \right)$ with $\ln A$ (if $R =$ radius of a nucleus and $A =$ its mass number)?

Answer: B

Solution:

$$\frac{R}{R_0} = A^{1/3} \Rightarrow \log \left( \frac{R}{R_0} \right) = \frac{1}{3} \log(A)$$

The slope $y = mx$ is $\frac{1}{3}$. Therefore, the correct figure is B.
Identify the logic operation performed by the given circuit:

A AND gate
B OR gate
C NOR gate
D NAND gate

Ans. A
Sol.

\[ \text{Output} = \overline{A} + \overline{B} = A \cdot B \]

Match List I with List II

<table>
<thead>
<tr>
<th>List I</th>
<th>List II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Facsimile</td>
<td>I. Static Document Image</td>
</tr>
<tr>
<td>B. Guided media Channel</td>
<td>II. Local Broadcast Radio</td>
</tr>
<tr>
<td>C. Frequency Modulation</td>
<td>III. Rectangular wave</td>
</tr>
<tr>
<td>D. Digital Signal</td>
<td>IV. Optical Fiber</td>
</tr>
</tbody>
</table>

Choose the correct answer from the following options:

A A-IV, B-III, C-II, D-I
B A-I, B-IV, C-II, D-III
C A-IV, B-II, C-III, D-I
D A-I, B-II, C-III, D-IV

Ans. B
20. If \( n \) represents the actual number of deflections in a converted galvanometer of resistance \( G \) and shunt resistance \( S \). Then the total current \( I \) when its figure of merit is \( K \) will be:

A. \( \frac{KS}{S+G} \)
B. \( \frac{(G+S)}{nKS} \)
C. \( \frac{nKS}{G+S} \)
D. \( \frac{nK(G+S)}{S} \)

Ans. D

Sol.

Given figure of merit \( K = \frac{I}{n} \)

\[ I = \frac{I_g(R_g + S)}{S} \]

\[ I = \frac{nk(G+s)}{s} \]

21. For \( z = a^2x^3y^2 \), where ‘\( a \)’ is a constant. If percentage error in measurement of ‘\( x \)’ and ‘\( y \)’ are 4% and 12%, respectively, then the percentage error for ‘\( z \)’ will be \( \_\_\_\_\_\_\% \).

Ans. 18.00

Sol.

\[ R = a^2x^3y^{1/2} \]

\[ \frac{\Delta R}{R_{\max}} \times 100 = 3 \left( \frac{\Delta x}{x} \times 100 \right) + \frac{1}{2} \left( \frac{\Delta y}{y} \times 100 \right) \]

\[ = 3 \times (4) + \frac{1}{2} \times (12) \]

\[ = 12 + 6 = 18\% \]

22. A curved in a level road has a radius 75 m. The maximum speed of a car turning this curved road can be 30 m/s without skidding. If radius of curved road is changed to 48 m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be \( \_\_\_\_\_\_\_ \) m/s.

Ans. 24.00
Sol. \[
\tan \theta = \frac{v_2^2}{Rg}, \text{ then } v \propto \sqrt{f}
\]
\[
\frac{v_2}{v_1} = \frac{\sqrt{2}}{\sqrt{1}} = \frac{48}{75}
\]
\[
v_2 = \frac{4}{5} \times 30 = 24 \text{ m/s}
\]

23. A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force \( F = \sqrt{xN} \) as shown in figure.

\[
A \text{ long surface}
\]
\[
F \cos 60^\circ = mg \sin 60^\circ
\]
\[
F = mg \tan 60^\circ = 200 \times 10 \times \sqrt{3} \times 10^{-3} = 2\sqrt{3} = \sqrt{12} \text{ N}
\]

Ans. 12.00
24 Moment of Inertia (M.I.) of four bodies having same mass ‘M’ and radius ‘2R’ are as follows:
I₁ = M.I. of solid sphere about its diameter
I₂ = M.I. of solid cylinder about its axis
I₃ = M.I. of solid circular disc about its diameter
I₄ = M.I. of thin circular ring about its diameter
If 2(I₂ + I₃) + I₄ = x · I₁ then the value of x will be ________.

Ans. 05.00

Sol. 2(I₂ + I₃) + I₄ = x · I₁
2\left[\frac{MR^2}{2} + \frac{MR^2}{4}\right] + \frac{MR^2}{2} = x \left[\frac{2}{5}MR^2\right]
2MR^2 = x \left[\frac{2}{5}MR^2\right]
x = 5

25 Two satellites S₁ and S₂ are revolving in circular orbits around a planet with radius R₁ = 3200 km and R₂ = 800 km respectively. The ratio of speed of satellite S₁ to the speed of satellite S₂ in their respective orbits would be \frac{1}{x} where x = ________.

Ans. 02.00

Sol.
V \propto \frac{1}{\sqrt{R}}
\frac{V₁}{V₂} = \sqrt{\frac{R₂}{R₁}} = \sqrt{\frac{800}{3200}} = \frac{1}{2}

26 When a gas filled in a closed vessel is heated by raising the temperature by 1°C, its pressure increases by 0.4%. The initial temperature of the gas is ________ K.

Ans. 250

Sol. Given ΔT = 1, ΔP = 0.4%
P \propto \frac{\Delta T}{T}
\frac{\Delta P}{P} = \frac{\Delta T}{T}
0.4 = \frac{1 \times 100}{T}
T = 250
27. Identical drops are charged at \(22V\) each. They combine to form a bigger drop. The potential of the bigger drop will be _________ \(V\).

**Ans.** 198

**Sol.**

\[
R = (27)^{1/3}r = 3r
\]

\[
V = \frac{KQ}{R} = \frac{K(27q)}{3r} = 9 \times 22 = 198 \text{ Volt}
\]

28. The length of a given cylindrical wire is increased to double of its original length. The percentage increase in the resistance of the wire will be _________%.

**Ans.** 300

**Sol.**

\[
R' = n^2 R
\]

\[
R' = 4R
\]

\[
\% \text{ change} = \left( \frac{R' - R}{R} \right) \times 100 = \left( \frac{4R - R}{R} \right) \times 100 = 300\%.
\]

29. In a series LCR circuit, the inductance, capacitance and resistance are \(L = 100 \text{ mH}\), \(C = 100 \mu \text{F}\) and \(R = 10 \Omega\) respectively. They are connected to an AC source of voltage \(220 \text{ V}\) and frequency of \(50 \text{ Hz}\). The approximate value of current in the circuit will be _________ \(A\).

**Ans.** 22.00

**Sol.**

\[
X_C = \frac{1}{\omega C} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}} = \frac{100}{\pi} = 10\pi \Omega
\]

\[
X_L = \omega L = 2\pi \times 50 \times 100 \times 10^{-3} = 10\pi \Omega
\]

\[
X = X_C - X_L = 10\pi - 10\pi = 0
\]

\[
\text{Current} = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + X^2}} = \frac{220}{10} = 22A
\]
In an experiment of $CE$ configuration of n-p-n transistor, the transfer characteristics are observed as given in figure.

If the input resistance is 200 $\Omega$ and output resistance is 60 $\Omega$, the voltage gain in this experiment will be________.  

Ans. 15.00  
Sol.  
$$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B} = \frac{5 \times 10^{-3}}{100 \times 10^{-6}} = 50$$  
$$A_v = \beta_{AC} \times \frac{R_{out}}{R_{in}} = (50) \left( \frac{60}{200} \right) = 15$$
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