## Evening

Corporate Office : Aakash Tower, 8, Pusa Road, New Delhi-110005 | Ph.: 011-47623456

## Answers \& Solutions

Time : 3 hrs.
M.M. : $\mathbf{3 0 0}$

## JEE (Main)-2024 (Online) Phase-1

## (Mathematics, Physics and Chemistry)

## IMPORTANT INSTRUCTIONS:

(1) The test is of $\mathbf{3}$ hours duration.
(2) This test paper consists of 90 questions. Each subject (MPC) has 30 questions. The maximum marks are 300 .
(3) This question paper contains Three Parts. Part-A is Mathematics, Part-B is Physics and Part-C is Chemistry. Each part has only two sections: Section-A and Section-B.
(4) Section - A : Attempt all questions.
(5) Section - B : Attempt any 05 questions out of 10 Questions.
(6) Section-A (01-20) contains 20 multiple choice questions which have only one correct answer. Each question carries $\mathbf{+ 4}$ marks for correct answer and $\mathbf{- 1}$ mark for wrong answer.
(7) Section-B(21-30) contains 10 Numerical value based questions. The answer to each question should be rounded off to the nearest integer. Each question carries $\mathbf{+ 4} \mathbf{~ m a r k s}$ for correct answer and -1 mark for wrong answer.


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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 $f: \rightarrow \mathbb{R} \rightarrow(0, \infty)$ be strictly increasing function such that $\lim _{x \rightarrow \infty} \frac{f(7 x)}{f(x)}=1$. Then, the value of $\lim _{x \rightarrow \infty}\left[\frac{f(5 x)}{f(x)}-1\right]$ is equal to
(1) 0
(2) $7 / 5$
(3) 1
(4) 4

Answer (1)
Sol. $f(x) \leq f(5 x) \leq f(7 x), \forall x>0$

$1 \leq \frac{f(5 x)}{f(x)} \leq \frac{f(7 x)}{f(x)}$
As $x \rightarrow \infty, \frac{f(5 x)}{f(x)} \rightarrow 1^{+}$
$\lim _{x \rightarrow \infty}\left[\frac{f(5 x)}{f(x)}-1\right]=0$
2. If for some $m$, $n:{ }^{6} C_{m}+2\left({ }^{6} C_{m+1}\right)+{ }^{6} C_{m+2}>{ }^{6} C_{3}$ and ${ }^{n-1} P_{3}:{ }^{n} P_{4}=1: 8$, then ${ }^{n} P_{m+1}+{ }^{n+1} C_{m}$ is equal to
(1) 376
(2) 372
(3) 384
(4) 380

Answer (2)

Sol. ${ }^{6} C_{m}+2\left({ }^{6} C_{m+1}\right)+{ }^{6} C_{m+2}>{ }^{8} C_{3}$
${ }^{6} C_{m}+{ }^{6} C_{m+1}+{ }^{6} C_{m+1}+{ }^{6} C_{m+2}>{ }^{8} C_{3}$
${ }^{7} C_{m+1}+{ }^{7} C_{m+2}>{ }^{8} C_{3}$
${ }^{8} C_{m+2}>{ }^{8} C_{3}$
$\Rightarrow m=2$
Now, $\frac{{ }^{n-1} P_{3}}{{ }^{n} P_{4}}=\frac{1}{8} \Rightarrow \frac{1}{n}=\frac{1}{8} \Rightarrow n=8$
Now, ${ }^{n} P_{m+1}+{ }^{n+1} C_{m}$
$={ }^{8} P_{3}+{ }^{9} \mathrm{C}_{2}$
$=\frac{8!}{5!}+\frac{9!}{2!7!}=336+36=372$
3. If the function $f:(-\infty,-1] \rightarrow(a, b]$ defined by $f(x)=e^{x^{3}-3 x+1}$ is one-one and onto, then the distance of the point $P(2 b+4, a+2)$ from the line $x+e^{-3} y=4$ is
(1) $\sqrt{1+e^{6}}$
(2) $3 \sqrt{1+e^{6}}$
(3) $2 \sqrt{1+e^{6}}$
(4) $4 \sqrt{1+e^{6}}$

Answer (3)
Sol. $f(x)=e^{x^{3}-3 x+1}$

$$
\begin{aligned}
f^{\prime}(x) & =e^{x^{3}-3 x+1}\left(3 x^{2}-3\right) \\
& =3 e^{x^{3}-3 x+1}(x-1)(x+1)
\end{aligned}
$$

For $x \in(-\infty,-1], f^{\prime}(x) \geq 0$
$\therefore f(x)$ is increasing function
$\therefore \quad a=e^{-\infty}=0=f(-\infty)$

$$
b=e^{-1+3+1}=e^{3}=f(-1)
$$

$\therefore \quad P\left(2 e^{3}+4,2\right)$


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$d=\frac{2 e^{3}+4+2 e^{-3}-4}{\sqrt{1+e^{-6}}}$

$d=\frac{2\left(\frac{\left(e^{6}+1\right.}{e^{3}}\right)}{\frac{\sqrt{e^{6}+1}}{e^{3}}} \Rightarrow d=2 \sqrt{1+e^{6}}$
4. Let $2^{\text {nd }}, 8^{\text {th }}$ and $44^{\text {th }}$ terms of a non-constant A.P. be respectively the $1^{\text {st }}, 2^{\text {nd }}$ and $3^{\text {rd }}$ terms of a G.P. If the first term of the A.P. is 1 , then the sum of its first 20 terms is equal to
(1) 990
(2) 960
(3) 980
(4) 970

## Answer (4)

Sol. $a+d, a+7 d, a+43 d$ are $1^{\text {st }}, 2^{\text {nd }}, 3^{\text {rd }}$ terms of a G.P.
$\frac{a+7 d}{a+d}=\frac{a+43 d}{a+7 d}$
$\Rightarrow(a+7 d)^{2}=(a+43 d)(a+d)$
$\Rightarrow a^{2}+49 d^{2}+14 a d=a^{2}+44 a d+43 d^{2}$
$\Rightarrow 6 d^{2}=30 a d$
$\Rightarrow d=0,5$
But $d \neq 0$
$\Rightarrow d=5, a=1$
$\mathrm{S}_{20},=\frac{20}{2}\left[2+(19)^{5}\right]$
$=10(95+2)=970$
5. Let $A$ be a $3 \times 3$ real matrix such that
$A\left(\begin{array}{l}1 \\ 0 \\ 1\end{array}\right)=2\left(\begin{array}{l}1 \\ 0 \\ 1\end{array}\right), A\left(\begin{array}{c}-1 \\ 0 \\ 1\end{array}\right)=4\left(\begin{array}{c}-1 \\ 0 \\ 1\end{array}\right), A\left(\begin{array}{l}0 \\ 1 \\ 0\end{array}\right)=2\left(\begin{array}{l}0 \\ 1 \\ 0\end{array}\right)$.
Then, the system $(A-3 /)\left(\begin{array}{l}x \\ y \\ z\end{array}\right)=\left(\begin{array}{l}1 \\ 2 \\ 3\end{array}\right)$ has
(1) No solution
(2) Exactly two solutions
(3) Infinitely many solutions
(4) Unique solution

## Answer (4)

Sol. Let $A=\left(\begin{array}{lll}x_{1} & y_{1} & z_{1} \\ x_{2} & y_{2} & z_{2} \\ x_{3} & y_{3} & z_{3}\end{array}\right)$
Given $A\left(\begin{array}{l}1 \\ 0 \\ 1\end{array}\right)=\left(\begin{array}{l}2 \\ 0 \\ 2\end{array}\right)$

$$
\begin{align*}
\Rightarrow & \left(\begin{array}{l}
x_{1}+z_{1} \\
x_{2}+z_{2} \\
x_{3}+z_{3}
\end{array}\right)=\left(\begin{array}{l}
2 \\
0 \\
2
\end{array}\right) \\
\therefore & x_{1}+z_{1}=2  \tag{2}\\
& x_{2}+z_{2}=0  \tag{3}\\
& x_{3}+z_{3}=0 \tag{4}
\end{align*}
$$

Similarly, from $A\left(\begin{array}{c}-1 \\ 0 \\ 1\end{array}\right)=\left(\begin{array}{c}-4 \\ 0 \\ 4\end{array}\right)$
$\Rightarrow-x_{1}+z_{1}=-4$

Similarly, from $A\left(\begin{array}{l}0 \\ 1 \\ 0\end{array}\right)=\left(\begin{array}{l}0 \\ 2 \\ 0\end{array}\right)$
$\Rightarrow y_{1}=0, y_{2}=2, y_{3}=0$
From (2), (3), (4), (5), (6) and (7)
$x_{1}=3, x_{2}=0, x_{3}=-1$
$y_{1}=0, y_{2}=2, y_{3}=0$
$z_{1}=-1, z_{2}=0, z_{3}=3$


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$\therefore \quad A=\left(\begin{array}{ccc}3 & 0 & -1 \\ 0 & 2 & 0 \\ -1 & 0 & 3\end{array}\right)$
Now, $(A-3 /)\left(\begin{array}{l}x \\ y \\ z\end{array}\right)=\left(\begin{array}{l}1 \\ 2 \\ 3\end{array}\right)$
$\Rightarrow\left(\begin{array}{ccc}0 & 0 & -1 \\ 0 & -1 & 0 \\ -1 & 0 & 0\end{array}\right)\left(\begin{array}{l}x \\ y \\ z\end{array}\right)=\left(\begin{array}{l}1 \\ 2 \\ 3\end{array}\right)$
$\Rightarrow \quad z=-1, y=-2$ and $x=-1$
(Unique solution)
6. Let $P$ be a parabola with vertex $(2,3)$ and directrix $2 x+y=6$. Let an ellipse $E: \frac{x^{2}}{a^{2}}+\frac{y^{2}}{b^{2}}=1, a>b$, of eccentricity $\frac{1}{\sqrt{2}}$ pass through the focus of the parabola $P$. Then, the square of the length of the latus rectum of $E$, is
(1) $\frac{347}{8}$
(2) $\frac{512}{25}$
(3) $\frac{385}{8}$
(4) $\frac{656}{25}$

Answer (4)

Sol.

$2 x+y=6$
Let $z$ be the foot of perpendicular from vertex $(2,3)$ to the directrix.
$\therefore \quad \frac{x-2}{2}=\frac{y-3}{1}=-\frac{(4+3-6)}{5}$
$\therefore \quad z \equiv\left(\frac{8}{5}, \frac{14}{5}\right)$
$\because(2,3)$ is the mid-point of $z$ and focus $F$.
$\therefore \quad(\alpha, \beta) \equiv\left(\frac{12}{5}, \frac{16}{5}\right)$
$\because$ Eccentricity of ellipse $\frac{x^{2}}{a^{2}}+\frac{y^{2}}{b^{2}}=1$
Where $a>b$ is $\frac{1}{\sqrt{2}}$
$\therefore \quad b^{2}=\frac{a^{2}}{2}$
$\therefore \quad \frac{144}{25 a^{2}}+\frac{256}{25 \times \frac{a^{2}}{2}}=1$
$\Rightarrow a^{2}=\frac{656}{25} \Rightarrow a=\frac{\sqrt{656}}{5}$
Square of length of latus rectum of $E$
$=4\left(\frac{b^{2}}{a}\right)^{2}$
$=4 \cdot \frac{a^{2}}{4}=\frac{656}{25}$
7. The shortest distance, between lines $L_{1}$ and $L_{2}$, where $L_{1}: \frac{x-1}{2}=\frac{y+1}{-3}=\frac{z+4}{2}$ and $L_{2}$ is the line, passing through the points $A(-4,4,3), B(-1,6,3)$ and perpendicular to the line $\frac{x-3}{-2}=\frac{y}{3}=\frac{z-1}{1}$, is
(1) $\frac{141}{\sqrt{221}}$
(2) $\frac{24}{\sqrt{117}}$
(3) $\frac{121}{\sqrt{221}}$
(4) $\frac{42}{\sqrt{117}}$

Answer (1)
Sol. $L_{1}: \frac{x-1}{2}=\frac{y+1}{-3}=\frac{z+4}{2}$
$L_{2}$ is line passing through $A(-4,4,3) \& B(-1,6,3)$
$\therefore$ Equation of line $L_{2}: \frac{x+4}{3}=\frac{y-4}{2}=\frac{z-3}{0}$
Which is perpendicular to $\frac{x-3}{-2}=\frac{y}{3}=\frac{z-1}{1}$


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$\therefore \quad$ Distance between $L_{1}$ and $L_{2}$ is :

$$
\begin{aligned}
& \frac{\left|\begin{array}{ccc}
-5 & 5 & 7 \\
2 & -3 & 2 \\
3 & 2 & 0
\end{array}\right|}{\sqrt{(-3-4)^{2}+(0-6)^{2}+(4+9)^{2}}}=\frac{20+30+91}{\sqrt{16+36+169}} \\
& =\frac{141}{\sqrt{221}}
\end{aligned}
$$

8. The area of the region enclosed by the parabolas $y=4 x-x^{2}$ and $3 y=(x-4)^{2}$ is equal to
(1) $\frac{14}{3}$
(2) $\frac{32}{9}$
(3) 4
(4) 6

Answer (4)

Sol.


$$
\begin{aligned}
\text { Area } & =\left\lvert\, \int_{1}^{4}\left[(4-x)^{2}-\frac{(x-4)^{2}}{3}\right] d x\right. \\
\text { Area } & =\left|4 x-\frac{x^{3}}{3}-\frac{(x-4)^{3}}{9}\right|_{1}^{4} \\
& =\left|\left(16-\frac{64}{3}\right)-\left(4-\frac{1}{3}+\frac{27}{9}\right)\right| \\
& =\left|16-\frac{64}{3}-4+\frac{1}{3}+3\right| \\
& =|15-21|=6
\end{aligned}
$$

9. The number of ways in which 21 identical apples can be distributed among three children such that each child gets at least 2 apples, is
(1) 406
(2) 130
(3) 136
(4) 142

Answer (3)
Sol. After giving 2 apples to each child.
15 apples left now 15 apples can be distributed in

$$
\begin{aligned}
{ }^{15+3-1} C_{2}={ }^{17} C_{2} \\
=\frac{17 \times 16}{2}=136
\end{aligned}
$$

$\therefore$ Option (3) is correct.
10. Let a variable line passing through the centre of the circle $x^{2}+y^{2}-16 x-4 y=0$, meet the positive coordinate axes at the points $A$ and $B$. Then the minimum value of $O A+O B$, where $O$ is the origin, is equal to
(1) 12
(2) 18
(3) 20
(4) 24

## Answer (2)

Sol. Given $x^{2}+y^{2}-16 x-4 y=0$
$\Rightarrow(x-4)^{2}+(y-2)^{2}=20$
As variable line passes through center of circle $\therefore(y-2)=m(x-8)$
$\therefore \quad X$ intercept $=\left(\frac{-2}{m}+8\right)$
$Y$ intercept $=(-8 m+2)$
$O A+O B=\frac{-2}{m}+8-8 m+2$
$f^{\prime}(m)=\frac{2}{m^{2}}-8=0$
$\Rightarrow m^{2}=\frac{1}{4}$
$\Rightarrow m=\frac{-1}{2}$
$\therefore f\left(\frac{-1}{2}\right)=18$
Option (2) is correct


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11. Let the mean and the variance of 6 observations $a, b, 68,44,48,60$ be 55 and 194, respectively. If $a>b$, then $a+3 b$ is
(1) 180
(2) 210
(3) 190
(4) 200

Answer (1)
Sol. Mean $=55=\bar{X}$
$\frac{a+b+68+44+48+60}{6}=55$
$a+b+220=330$
$a+b=110$
$a>b$
Variance is 194
$\frac{\sum x_{i}{ }^{2}}{n}-(\bar{X})^{2}=194$
$\frac{\sum x_{i}^{2}}{6}=3219$
$\sum x_{i}^{2}=19314$
$a^{2}+b^{2}=6850$
$a>b$
$a=75, b=35$
$a+3 b=75+105=180$
12. If $a=\sin ^{-1}(\sin (5))$ and $b=\cos ^{-1}(\cos (5))$, then $a^{2}+b^{2}$ is equal to
(1) $4 \pi^{2}-20 \pi+50$
(2) 25
(3) $4 \pi^{2}+25$
(4) $8 \pi^{2}-40 \pi+50$

## Answer (4)

Sol. $a=\sin ^{-1}(\sin (5))$

$$
\begin{aligned}
& b= \\
& \cos ^{-1}(\cos (5)) \\
& a= \\
& \sin ^{-1}(\sin (5)) \\
& \\
& = \\
& b=\cos ^{-1}(\cos (5)) \\
& \\
& =2 \pi-5 \\
& \begin{aligned}
a^{2}+ & b^{2}=(5-2 \pi)^{2}+(2 \pi-5)^{2} \\
& =25+4 \pi^{2}-20 \pi+4 \pi^{2}+25-20 \pi \\
& =8 \pi^{2}-40 \pi+50
\end{aligned}
\end{aligned}
$$

13. Let $(\alpha, \beta, \gamma)$ be the mirror image of the point $(2,3,5)$ in the line $\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}$. Then $2 \alpha+3 \beta+4 \gamma$ is equal to
(1) 34
(2) 31
(3) 32
(4) 33

## Answer (4)

Sol.


Take
$\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}=\lambda$
$x=2 \lambda+1, y=3 \lambda+2, z=4 \lambda+3$
$\overrightarrow{A B}=(\alpha-2) \hat{i}+(\beta-3) \hat{j}+(\gamma-5) \hat{k}$
Now, $(\alpha-2) \cdot 2+(\beta-3) \cdot 3+(\gamma-5) \cdot 4=0$
$\Rightarrow 2 \alpha-4+3 \beta-9+4 \gamma-20=0$
$\Rightarrow 2 \alpha+3 \beta+4 \gamma=33$
14. A coin is biased so that a head is twice as likely to occur as a tail. If the coin is tossed 3 times, the probability of getting two tails and one head is
(1) $\frac{2}{9}$
(2) $\frac{1}{9}$
(3) $\frac{1}{27}$
(4) $\frac{2}{27}$

## Answer (1)

Sol. H: Getting a head on tossing the given coin
T: Getting a tail on tossing the given coin
$P(H)=\frac{2}{3}$
$P$ (Getting two tails and a head on tossing the coin three times)

$$
=3\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)^{2}=\frac{2}{9}
$$



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15. Let $f, g:(0, \infty) \rightarrow \mathbb{R}$ be two functions defined by $f(x)=\int_{-x}^{x}\left(|t|-t^{2}\right) e^{-t^{2}} d t$ and $g(x)=\int_{0}^{x^{2}} t^{1 / 2} e^{-t} d t$. Then, the value of $9\left(f\left(\sqrt{\log _{e} 9}\right)+g\left(\sqrt{\log _{e} 9}\right)\right)$ is equal to
(1) 10
(2) 9
(3) 6
(4) 8

Answer (4)
Sol. $f(x)=2 \int_{0}^{x}\left(t-t^{2}\right) e^{-t^{2}} d t$
Put $t^{2}=z \quad \Rightarrow 2 t d t=d z$
$f(x)=\int_{0}^{x^{2}}(1-\sqrt{z}) e^{-z} d z$
Switching back to $t$
$f(x)=\int_{0}^{x^{2}}(1-\sqrt{t}) e^{-t} d t$
And $g(x)=\int_{0}^{x^{2}} \sqrt{t} e^{-t} d t$
$h(x)=f(x)+g(x)=\int_{0}^{x^{2}} e^{-t} d t=1-e^{-x^{2}}$
$h\left(\sqrt{\log _{e} g}\right)=1-e^{-\log _{e} g}=1-\frac{1}{9}=\frac{8}{9}$
Required value $=9 \times \frac{8}{9}=8$
16. Let $z_{1}$ and $z_{2}$ be two complex numbers such that $z_{1}+z_{2}=5$ and $z_{1}^{3}+z_{2}^{3}=20+15 i$. Then, $\left|z_{1}^{4}+z_{2}^{4}\right|$ equals
(1) 75
(2) $25 \sqrt{3}$
(3) $15 \sqrt{15}$
(4) $30 \sqrt{3}$

Answer (1)
Sol. $z_{1}+z_{2}=5$

$$
\begin{aligned}
& z_{1}^{3}+z_{2}^{3}=20+15 i \\
& z_{1}^{3}+z_{2}^{3}=\left(z_{1}+z_{2}\right)^{3}-3 z_{1} z_{2}\left(z_{1}+z_{2}\right) \\
& =125-15 z_{1} z_{2}=20+15 i
\end{aligned}
$$

$$
\begin{aligned}
& \Rightarrow z_{1} z_{2}=7-i \\
& \left(z_{1}+z_{2}\right)^{2}=25 \\
& \Rightarrow z_{1}^{2}+z_{2}^{2}=25-2(7-i)=11+2 i \\
& \left(z_{1}^{2}+z_{2}^{2}\right)^{2}=z_{1}^{4}+z_{2}^{4}+2 z_{1}^{2} z_{2}^{2}=117+44 i \\
& \Rightarrow\left(z_{1}^{4}+z_{2}^{4}\right)=21+72 i \\
& \Rightarrow\left|z_{1}^{4}+z_{2}^{4}\right|=75
\end{aligned}
$$

17. The number of solutions, of the equation $e^{\sin x}-2 e^{-\sin x}=2$, is
(1) 0
(2) 1
(3) 2
(4) More than 2

Answer (1)
Sol. $e^{\sin x}-2 e^{-\sin x}=2$
Let $y=e^{\sin x}, e^{\sin x}>0 \forall x \Rightarrow y>0$
$\Rightarrow y-\frac{2}{y}=2 \Rightarrow y^{2}-2 y-2=0$

$$
\Rightarrow(y-1)^{2}=3
$$

$\Rightarrow y=\sqrt{3}+1$
$\Rightarrow e^{\sin x}=\sqrt{3}+1$
$\sin x=\ln (\sqrt{3}+1)>1$
$\Rightarrow$ No solution $\quad \Rightarrow$ Number of solution is zero
18. Let $A(a, b), B(3,4)$ and $C(-6,-8)$ respectively denote the centroid, circumcentre and orthocentre of a triangle. Then, the distance of the point $P(2 a+3,7 b+5)$ from the line $2 x+3 y-4=0$ measured parallel to the line $x-2 y-1=0$ is
(1) $\frac{17 \sqrt{5}}{7}$
(2) $\frac{15 \sqrt{5}}{7}$
(3) $\frac{\sqrt{5}}{17}$
(4) $\frac{17 \sqrt{5}}{6}$

## Answer (1)



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Sol. Centroid divides orthocentre and circumcentre in 2:1.

$$
\begin{aligned}
& 2: 1 \\
& (-6,-8) \quad(a, b) \quad(3,4) \\
& a \equiv \frac{2(3)-6}{3}=0 \\
& b \equiv \frac{2(4)-8}{3}=0 \\
& \Rightarrow \quad(a, b) \equiv(0,0) \\
& \Rightarrow P \equiv(3,5)
\end{aligned}
$$


$\Rightarrow \quad(y-5)=\frac{1}{2}(x-3)$
$\Rightarrow 2 y-10=x-3$
$\Rightarrow 2 y-x=7$
$\Rightarrow \sqrt{\left(3+\frac{13}{7}\right)^{2}+\left(5-\frac{18}{7}\right)^{2}}=\frac{\sqrt{34^{2}+17^{2}}}{7}$
$=\frac{17 \sqrt{5}}{7}$
19. The temperature $T(t)$ of a body at time $t=0$ is $160^{\circ} \mathrm{F}$ and it decreases continuously as per the differential equation $\frac{d T}{d t}=-K(T-80)$, where $K$ is a positive constant. If $T(15)=120^{\circ} \mathrm{F}$, then $T(45)$ is equal to
(1) $95^{\circ} \mathrm{F}$
(2) $90^{\circ} \mathrm{F}$
(3) $80^{\circ} \mathrm{F}$
(4) $85^{\circ} \mathrm{F}$

Answer (2)

Sol. $\frac{d T}{d t}=-K(T-80)$
$\Rightarrow \frac{d T}{T-80}=-K d t$
$\Rightarrow$ Integrating,

$$
\begin{aligned}
& \ln |T-80|=-K t+C \\
& \text { at } t=0, T=160^{\circ} \mathrm{F} \\
& \ln |(80)|=C \\
\Rightarrow & \ln |T-80|=-K t+\ln 80 \\
\Rightarrow & \ln \left|\frac{T-80}{80}\right|=-K t \\
\Rightarrow & \left|\frac{T-80}{80}\right|=e^{-K t} \\
& \text { at } T(15)=120^{\circ} \mathrm{F} \\
\Rightarrow & \frac{40}{80}=e^{-K(15)} \Rightarrow \frac{1}{2}=e^{-15 K} \\
\Rightarrow & -\ln 2=-15 K \Rightarrow K=\frac{\ln 2}{15} \\
\Rightarrow & \frac{|T-80|}{80}=e^{-45 K}=\left(e^{-15 K}\right)^{3}=\left(\frac{1}{2}\right)^{3}=\frac{1}{8} \\
\Rightarrow & |T-80|=10 \Rightarrow T=90^{\circ} F
\end{aligned}
$$

20. Consider the function $f:(0, \infty) \rightarrow \mathbb{R}$ defined by $f(x)=e^{-\left|\log _{e} x\right|}$. If $m$ and $n$ be respectively the number of points at which $f$ is not continuous and $f$ is not differentiable, then $m+n$ is
(1) 1
(2) 3
(3) 2
(4) 0

## Answer (1)

Sol. $f(x)=e^{-\left|\log _{e} x\right|}, x \in(0, \infty)$

$$
f(x)= \begin{cases}e^{\ln x}, & x \in(0,1) \\ e^{-\ln x}, & x \in[1, \infty)\end{cases}
$$



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$f(x)$ is continuous for $\forall x \in R \Rightarrow m=0$ and $f(x)$ is not differentiable at $x=1$
$n \Rightarrow 1$
$m+n=1$

## SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. Attempt any 5 questions out of 10 . The answer to each question should be rounded-off to the nearest integer.
21. Let $A$ be a $3 \times 3$ matrix and $\operatorname{det}(A)=2$. If $n=\operatorname{det}(\underbrace{\operatorname{adj}(\operatorname{adj}(\ldots . .(\operatorname{adj} A)))) \text {, then the remainder }}_{2024-\text { times }}$ when $n$ is divided by 9 is equal to $\qquad$ .
Answer (7)
Sol. $|A|=2$

$$
\begin{aligned}
& n=\underbrace{\mid(\operatorname{adj}(\operatorname{adj} \ldots(\operatorname{adj} A)) \mid}_{2024 \text { times }} \\
& |\operatorname{adj} A|=|A|^{2} \\
& |\operatorname{adj}(\operatorname{adj} \ldots . .(\operatorname{adj} A))|=|A|^{2^{2024}} \\
& \quad=2^{2^{2024}} \\
& \because 2^{2024}=4^{1012}=(3+1)^{1012}=3 k+1
\end{aligned}
$$

where $k$ is odd
$\mid \operatorname{adj}\left(\operatorname{adj} . . . . . . \operatorname{adj}(A) \mid=2^{3 k+1}=2.8^{k}\right.$
$2(9-1)^{k}=9 m-2$
$=9 P+7$
$\Rightarrow$ Remainder $=7$
22. Let the coefficient of $x^{r}$ in the expansion of

$$
\begin{aligned}
& (x+3)^{n-1}+(x+3)^{n-2}(x+2)+(x+3)^{n-3}(x+2)^{2}+ \\
& \ldots \ldots . .(x+2)^{n-1} \text { be } \alpha y . \text { If } \sum_{r=0}^{n} \alpha_{r}=\beta^{n}-\gamma^{n}, \beta, \gamma \in \mathbb{N},
\end{aligned}
$$

then the value of $\beta^{2}+\gamma^{2}$ equals $\qquad$ .

Answer (25)
Sol. $(x+3)^{n-1} \frac{\left[1-\left(\frac{x+2}{x+3}\right)^{n}\right]}{\frac{1}{(x+3)}}$
$=(x+3)^{n}\left(1-\left(\frac{x+2}{x+3}\right)^{n}\right)$
$=(x+3)^{n}-(x+2)^{n}$
Coefficient of $x^{r}={ }^{n} C_{r} 3^{n-r}-{ }^{n} C_{r} 2^{n-r}=a_{r}$
$\sum_{r=0}^{n}\left({ }^{n} C_{r} 3^{n-r}-{ }^{n} C_{r} 2^{n-r}\right)$

$$
=\left({ }^{n} C_{0} 3^{n}+{ }^{n} C_{1} 3^{n-1}+\ldots . .+{ }^{n} C_{n}\right)
$$

$$
-\left({ }^{n} C_{0} 2^{n}+{ }^{n} C_{1} 2^{n-1}+\ldots . .+{ }^{n} C_{n}\right)
$$

$$
=(3+1)^{n}-(2+1)^{n}
$$

$$
=4^{n}-3^{n} \equiv \beta^{n}-\gamma^{n}
$$

$$
\beta=4 \quad \gamma=3
$$

$$
\beta^{2}+\gamma^{2}=4^{2}+3^{2}=25
$$

23. $\left|\frac{120}{\pi^{3}} \int_{0}^{\pi} \frac{x^{2} \sin x \cos x}{\sin ^{4} x+\cos ^{4} x} d x\right|$ is equal to $\qquad$ .

Answer (15)


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Sol. $I=\int_{0}^{\pi} \frac{x^{2} \sin x \cos x}{\sin ^{4} x+\cos ^{4} x} d x$
$2 I=\int_{0}^{\pi} \frac{\sin x \cos x}{\sin ^{4} x+\cos ^{4} x}\left(x^{2}-(\pi-x)^{2}\right) d x$
$2 I=\int_{0}^{\pi} \frac{\pi(2 x-\pi) \sin x \cos x}{\sin ^{4} x+\cos ^{4} x} d x$
$\Rightarrow \quad I=\pi \int_{0}^{\pi / 2} \frac{(2 x-\pi) \sin x \cos x}{\sin ^{4} x+\cos ^{4} x} d x$
$\Rightarrow \quad I=\pi \int_{0}^{\pi / 2} \frac{-2 x \sin x \cos x}{\sin ^{4} x+\cos ^{4} x} d x$
$2 I=-\pi^{2} \int_{0}^{\pi / 2} \frac{\sin x \cos x}{\sin ^{4} x+\cos ^{4} x} d x$
$I=\frac{-\pi}{2 \times 2} \int_{0}^{\pi / 2} \frac{\sin 2 x}{\sin ^{4} x+\cos ^{4} x} d x$
$I=\frac{-\pi^{2}}{4} \int_{0}^{\pi / 2} \frac{2 \tan x \sec ^{2} x}{\tan ^{4} x+1} d x$
$I=\frac{-\pi^{2}}{4} \tan ^{-1}\left(\tan ^{2} x\right)_{0}^{\pi / 2}$
$\Rightarrow \quad I=\frac{-\pi^{3}}{8}$
$\therefore \quad\left|\frac{120}{\pi^{3}} l\right|=15$
24. Let $y=y(x)$ be the solution of the differential equation $\sec ^{2} x d x+\left(e^{2 y} \tan ^{2} x+\tan x\right) d y=0$, $0<x<\frac{\pi}{2}, y\left(\frac{\pi}{4}\right)=0$. If $y\left(\frac{\pi}{6}\right)=\alpha$, then $e^{8 \alpha}$ is equal to $\qquad$ .

## Answer (9)

Sol. $\sec ^{2} x \frac{d x}{d t}+e^{2 y} \tan ^{2} x+\tan x=0$
Put $\tan x=t$
$\Rightarrow \sec ^{2} x \frac{d x}{d y}=\frac{d t}{d y}$
$\frac{d t}{d y}+e^{2 y} \times t^{2}+1=0$
$\frac{1}{t^{2}} \frac{d t}{d y}+\frac{1}{t}=-e^{2 y}$
Put $\frac{1}{t}=u$
$\frac{-1}{t^{2}} \frac{d t}{d y}=\frac{d u}{d y}$
$\frac{-d u}{d y}+u=e^{2 y}$
IF $=e^{-y}$
$u e^{-y}=\int e^{-y} e^{2 y}$
$\frac{1}{\tan x} \times e^{-y}=e^{y}+c$
$x=\frac{\pi}{4} \quad y=0 \quad c=0$
$x=\frac{\pi}{4} \quad y=\alpha$
$\sqrt{3} e^{-\alpha}=e^{\alpha}+0$
$\Rightarrow e^{2 \alpha}=\sqrt{3}$
$e^{8 \alpha}=9$
25. Let $A=\{1,2,3, \ldots, 100\}$. Let $R$ be a relation on $A$ defined by $(x, y) \in R$ if and only if $2 x=3 y$. Let $R_{1}$ by a symmetric relation on $A$ such that $R \subset R_{1}$ and the number of elements in $R_{1}$ is $n$. Then, the minimum value of $n$ is $\qquad$

## Answer (66)

Sol. $R_{1}=\{(3,2),(6,4),(9,6),(12,8) \ldots(99.66)\}$ and symmetric elements
$\Rightarrow 2 \times 33=66$
$\Rightarrow n\left(R_{1}\right)=66$
26. If $\lim _{x \rightarrow 0} \frac{a x^{2} e^{x}-b \log _{e}(1+x)+c x e^{-x}}{x^{2} \sin x}=1$, then $16\left(a^{2}+b^{2}+c^{2}\right)$ is equal to $\qquad$
Answer (16)


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Sol. $\lim _{x \rightarrow 0} \frac{a x^{2} e^{x}-b \log _{e}(1+x)+c x e^{-x}}{x^{2} \sin x}=1$

$$
\begin{aligned}
& =\lim _{x \rightarrow 0} \frac{a x^{2} e^{x}-b \log _{e}(1+x)+c x e^{-x}}{x^{3} \times \frac{\sin x}{x}} \\
& =\lim _{x \rightarrow 0} \frac{a x^{2} e^{x}-b \log _{e}(1+x)+c x e^{-x}}{x^{3} \times 1} \\
& \quad a x^{2}\left(1+x+\frac{x^{2}}{2!}+\frac{x^{3}}{3!}+\ldots\right)-b\left(x-\frac{x^{2}}{2}+\frac{x^{3}}{3} \ldots\right) \\
& =\lim _{x \rightarrow 0} \frac{+c x\left(1-x+\frac{x^{2}}{2!}-\frac{x^{3}}{3!}+\ldots\right)}{x^{3}} \\
& =\lim _{x \rightarrow 0} \frac{(c-b) x+\left(\frac{b}{2}-c+a\right) x^{2}+\left(a-\frac{b}{3}+\frac{c}{2}\right) x^{3}+\ldots}{x^{3}}=1
\end{aligned}
$$

$$
\Rightarrow c-b=0, \frac{b}{2}-c+a=0 \text { and } a-\frac{b}{3}+\frac{c}{2}=0
$$

$$
\Rightarrow a=\frac{3}{4}, b=c=\frac{3}{2}
$$

$$
a^{2}+b^{2}+c^{2}=\frac{9}{16}+\frac{9}{4}+\frac{9}{4}=\frac{81}{16}
$$

27. A line passes through $A(4,-6,-2)$ and $B(16,-2,4)$.

The point $P(a, b, c)$, where $a, b, c$ are non-negative integers, on the line $A B$ lies at a distance of 21 units, from the point $A$. The distance between the points $P(a, b, c)$ and $Q(4,-12,3)$ is equal to $\qquad$

## Answer (22)

Sol. $\frac{x-4}{12}=\frac{y+6}{4}=\frac{z+2}{6}$
$\frac{x-4}{\frac{6}{7}}=\frac{y+6}{\frac{2}{7}}=\frac{z+2}{\frac{3}{7}}=21$

$$
\begin{aligned}
& \left(21 \times \frac{6}{7}+4, \frac{2}{7} \times 21-6, \frac{3}{7} \times 21-2\right) \\
& \equiv(22,0,7) \equiv(a, b, c): P \\
& P Q=\sqrt{324+144+16} \\
& \quad=22
\end{aligned}
$$

28. Let $a, b, c$ be the lengths of three sides of a triangle satisfying the condition $\left(a^{2}+b^{2}\right) x^{2}-2 b(a+c) x+$ $\left(b^{2}+c^{2}\right)=0$. If the set of all possible values of $x$ is the interval $(\alpha, \beta)$, then $12\left(\alpha^{2}+\beta^{2}\right)$ is equal to $\qquad$

## Answer (36)

Sol. $\left(a^{2}+b^{2}\right) x^{2}-2 b(a+c) x+\left(b^{2}+c^{2}\right)=0$

$$
\begin{aligned}
& \Rightarrow \quad\left(a^{2} x^{2}-2 a b+b^{2}\right)+\left(b^{2} x^{2}-2 b c x+c^{2}\right)=0 \\
& \Rightarrow \quad(a x-b)^{2}+(b x-c)^{2}=0 \\
& \Rightarrow x=\frac{b}{a} \text { and } x=\frac{c}{b} \Rightarrow b=a x \\
& \Rightarrow \quad \frac{b}{a}=\frac{c}{b} \Rightarrow b^{2}=a c
\end{aligned}
$$

Using triangular inequality

$$
a+b>c, b+c>a, c+a>b
$$

$\Rightarrow a+a x>b x$
$\Rightarrow a+a x>a x^{2}>0$
$\Rightarrow x^{2}-x-1<0$
Similarly, $a x+b x>a$
$\Rightarrow x^{2}+x-1>0$
$c+a>b$
$\Rightarrow x^{2}-x+1>0$ (always true)
$\Rightarrow x^{2}-x-1<0$ and $x^{2}+x-1>0$
$\Rightarrow x \in\left(\frac{1-\sqrt{5}}{2}, \frac{1+\sqrt{5}}{2}\right)$ and $x \in\left(\frac{\sqrt{5}-1}{2}, \frac{\sqrt{5}+1}{2}\right)$
$\Rightarrow \quad x \in\left(\frac{\sqrt{5}-1}{2}, \frac{\sqrt{5}+1}{2}\right)$
$\Rightarrow \quad \alpha^{2}+\beta^{2}=\left(\frac{\sqrt{5}-1}{2}\right)^{2}+\left(\frac{\sqrt{5}+1}{2}\right)^{2}=3$
$\Rightarrow 12\left(\alpha^{2}+\beta^{2}\right)=36$


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29. Let $A(-2,-1), B(1,0), C(\alpha, \beta)$ and $D(\gamma, \delta)$ be the vertices of a parallelogram $A B C D$. If the point $C$ lies on $2 x-y=5$ and the point $D$ lies on $3 x-2 y=6$, then the value of $|\alpha+\beta+\gamma+\delta|$ is equal to $\qquad$
Answer (32)

Sol.

$(\alpha, \beta)$ lie on $2 x-y=5$
$(\gamma, \delta)$ lie on $3 x-2 y=5$
$\Rightarrow \beta=2 \alpha-5$
$\delta=\frac{3 \gamma-6}{2}$
Also, mid-point of diagonal coincide
$\Rightarrow \frac{1+\gamma}{2}=\frac{\alpha-2}{2}$
$\Rightarrow \gamma=\alpha-3$
$\Rightarrow \quad \frac{0+\delta}{2}=\frac{\beta-1}{2}$
$\Rightarrow \delta=\beta-1$
$(\gamma, \delta)$ lie on (ii)
$\Rightarrow 3(\alpha-3)-2(\beta-1)=6$
$\Rightarrow 3 \alpha-2 \beta=13$
$2 \alpha-\beta=5$
$\Rightarrow \alpha=-3, \beta=-11$
$\Rightarrow \gamma=-6, \delta=-12$
$\Rightarrow|\alpha+\beta+\gamma+\delta|=32$
30. Let $\vec{a}=3 \hat{i}+2 \hat{j}+\hat{k}, \vec{b}=2 \hat{i}-\hat{j}+3 \hat{k}$ and $\vec{c}$ be a vector such that $(\vec{a}+\vec{b}) \times \vec{c}=2(\vec{a} \times \vec{b})+24 \hat{j}-6 \hat{k}$ and $(\vec{a}-\vec{b}+\hat{i}) \cdot \vec{c}=-3$. Then $|\vec{c}|^{2}$ is equal to

## Answer (38)

Sol. $(\vec{a}+\vec{b}) \times \vec{c}=2(\vec{a} \times \vec{b})+24 \hat{j}-6 \hat{k}$

$$
\begin{aligned}
& \Rightarrow(5 \hat{i}+\hat{j}+4 \hat{k}) \times \vec{c}=2(7 \hat{i}-7 \hat{j}-7 \hat{k})+24 \hat{j}-6 \hat{k} \\
& \Rightarrow \text { Let } \vec{c}=x \hat{i}+y \hat{j}+z \hat{k} \\
& \Rightarrow\left|\begin{array}{lll}
\hat{i} & \hat{j} & \hat{k} \\
5 & 1 & 4 \\
x & y & z
\end{array}\right|=14 \hat{i}+10 \hat{j}-20 \hat{k} \\
& \Rightarrow z-4 y=14 \\
& 4 x-5 z=10 \\
& 5 y-x=-20 \\
& \text { Also, }(a-b-i) \cdot \vec{c}=-3 \\
& \Rightarrow(2 \hat{i}+3 \hat{j}-2 \hat{k}) \cdot \vec{c}=-3 \\
& \Rightarrow 2 x+3 y-2 z=-3 \\
& \Rightarrow x=5,-3, z=2 \\
& |\vec{c}|=\sqrt{5^{2}+(-3)^{2}+(2)^{2}}=\sqrt{38} \\
& |\vec{c}|^{2}=38 \\
& \Rightarrow 2
\end{aligned}
$$



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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 :

31. The mass of the moon is $\frac{1}{144}$ times the mass of a planet and its diameter is $\frac{1}{16}$ times the diameter of a planet. If the escape velocity on the planet is $v$, the escape velocity on the moon will be
(1) $\frac{v}{12}$
(2) $\frac{v}{6}$
(3) $\frac{v}{4}$
(4) $\frac{v}{3}$

Answer (4)
Sol. $v_{e}=\sqrt{\frac{2 G M}{r}}$

$$
\begin{aligned}
& \Rightarrow \frac{v_{1}}{v_{2}}=\sqrt{\frac{M_{1} R_{2}}{M_{2} R_{1}}} \\
& \Rightarrow \frac{v}{v_{m}}=\sqrt{\frac{M_{1}}{\frac{1}{144} M_{1} R_{1}} \frac{1}{16} R_{1}}=\sqrt{9}=3
\end{aligned}
$$

32. A uniform magnetic field of $2 \times 10^{-3} T$ acts along positive $Y$-direction. A rectangular loop of sides 20 cm and 10 cm with current of $5 A$ is in $Y-Z$ plane. The current is in anticlockwise sense with reference to negative $X$ axis. Magnitude and direction of the torque is
(1) $2 \times 10^{-4} \mathrm{~N}$ - m along positive $Z$-direction
(2) $2 \times 10^{-4} \mathrm{~N}$-m along negative $Z$-direction
(3) $2 \times 10^{-4} \mathrm{~N}$-m along positive $Y$-direction
(4) $2 \times 10^{-4} \mathrm{~N}$-m along positive X -direction

Answer (2)

Sol. $m=i A$
$\tau=i A B$
$\tau=5 \times 200 \times 10^{-4} \times 2 \times 10^{-3}$
$=2 \times 10^{-4} \mathrm{Nm}$
$\hat{M}=-\hat{i} \quad \hat{B}=\hat{j}$
$\hat{M} \times \hat{B}\|-\hat{i} \times \hat{j}\|-\hat{k}$
33. Given below are two statements:

Statement I: Electromagnetic waves carry energy as they travel through space and this energy is equally shared by the electric and magnetic fields.
Statement II: When electromagnetic waves strike a surface, a pressure is exerted on the surface.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both Statement I and Statement II are correct
(2) Statement I is correct but Statement II is incorrect
(3) Statement I is incorrect but Statement II is correct
(4) Both Statement I and Statement II are incorrect
Answer (1)
Sol. $\Rightarrow$ EMW carries energy shared equally in magnetic and electric field.
$\Rightarrow$ EMW carrying momentum exerts force.
34. A gas mixture consists of 8 moles of argon and 6 moles of oxygen at temperature $T$. Neglecting all vibrational modes, the total internal energy of the system is
(1) $27 R T$
(2) 20 RT
(3) $21 R T$
(4) $29 R T$

Answer (1)
Sol. $U=\sum u_{i} f_{i} R T_{i}$

$$
\begin{aligned}
& =8 \times \frac{3}{2} R \times T+6 \times \frac{5}{2} R T \\
& =27 R T
\end{aligned}
$$



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35. In a photoelectric effect experiment a light of frequency 1.5 times the threshold frequency is made to fall on the surface of photosensitive material. Now if the frequency is halved and intensity is doubled, the number of photo electrons emitted will be
(1) halved
(2) doubled
(3) quadrupled
(4) Zero

## Answer (4)

Sol. $f_{i}=1.5 f_{o}$
$f_{i i}=0.75 f_{o}<f_{o}$
$\Rightarrow$ No electrons emitted
36. When unpolarized light is incident at an angle of $60^{\circ}$ on a transparent medium from air, the reflected ray is completely polarized. The angle of refraction in the medium is
(1) $30^{\circ}$
(2) $45^{\circ}$
(3) $60^{\circ}$
(4) $90^{\circ}$

Answer (1)
Sol.

$\Rightarrow r=30^{\circ}$
37. The mass number of nucleus having radius equal to half of the radius of nucleus with mass number 192 is
(1) 40
(2) 20
(3) 32
(4) 24

Answer (4)

Sol. $r_{2}=\frac{r_{1}}{2}, N_{2}=?, N_{1}=192$
$\left(\frac{r_{1}}{r_{2}}\right)^{3}=\frac{N_{1}}{N_{2}}$
$8=\frac{192}{N_{2}} \Rightarrow N_{2}=24$
38. Consider two physical quantities $A$ and $B$ related to each other as $E=\frac{B-x^{2}}{A t}$ where $E, x$ and $t$ have dimensions of energy, length and time respectively. The dimension of $A B$ is
(1) $L^{-2} M^{1} T^{0}$
(2) $L^{-2} M^{-1} T^{1}$
(3) $L^{0} M^{-1} T^{1}$
(4) $L^{2} M^{-1} T^{1}$

Answer (4)
Sol. $E=\frac{B-x^{2}}{A t} \Rightarrow B \equiv L^{2}$
and, $A \equiv \frac{L^{2}}{[E t]}$
$=\frac{L^{2}}{M L^{2} T^{-2}} \cdot T$
$A \equiv M^{-1} T$
$A B=M^{-1} L^{2} T$
39. The measured value of the length of a simple pendulum is 20 cm with 2 mm accuracy. The time for 50 oscillations was measured to be 40 seconds with 1 second resolution. From these measurements, the accuracy in the measurement of acceleration due to gravity is $N \%$. The value of $N$ is
(1) 5
(2) 8
(3) 4
(4) 6

Answer (4)


Sol. $T=2 \pi \sqrt{\frac{L}{g}}$
$\Rightarrow g=\frac{4 \pi^{2} L}{T^{2}}$
$\frac{\Delta g}{g}=\frac{\Delta L}{L}+\frac{20 T}{T}$
$\frac{\Delta g}{g} \times 100=\left(\frac{2}{200}+\frac{2}{40}\right) \times 100$
$=1+5$ = $6 \%$
40. The speed of sound in oxygen at S.T.P. will be approximately
(given, $R=8.3 \mathrm{JK}^{-1}, \gamma=1.4$ )
(1) $310 \mathrm{~m} / \mathrm{s}$
(2) $333 \mathrm{~m} / \mathrm{s}$
(3) $325 \mathrm{~m} / \mathrm{s}$
(4) $341 \mathrm{~m} / \mathrm{s}$

Answer (1)
Sol. $\because v=\sqrt{\frac{\gamma R T}{M_{0}}}$

$$
\Rightarrow v=\sqrt{\frac{1.4 \times 8.3 \times 273.15}{32 \times 10^{-3}}}=314 \mathrm{~m} / \mathrm{s}
$$

41. 



A block of mass 5 kg is placed on a rough inclined surface as shown in the figure. If $\vec{F}_{1}$ is the force required to just move the block up the inclined plane and $\vec{F}_{2}$ is the force required to just prevent the block from sliding down, then the value of $\left|\vec{F}_{1}\right|-\left|\vec{F}_{2}\right|$ is [Use $g=10 \mathrm{~m} / \mathrm{s}^{2}$ ]
(1) 10 N
(2) $\frac{5 \sqrt{3}}{2} \mathrm{~N}$
(3) $50 \sqrt{3} \mathrm{~N}$
(4) $25 \sqrt{3} \mathrm{~N}$

Answer (No option is correct)

Sol. $F_{1}=m g \sin \theta+\mu m g \cos \theta$
$F_{2}=m g \sin \theta-\mu m g \cos \theta$
$F_{1}-F_{2}=2 \mu \mathrm{mg} \cos \theta$
$=2 \times 0.1 \times 5 \times 10 \times \frac{\sqrt{3}}{2}$
$=5 \sqrt{3} \mathrm{~N}$
No option is correct.
42. An AC voltage $V=20 \sin 200 \pi t$ is applied to a series LCR circuit which drives a current $I=10$ sin $\left(200 \pi t+\frac{\pi}{3}\right)$. The average power dissipated is
(1) 50 W
(2) 200 W
(3) 173.2 W
(4) 21.6 W

Answer (1)
Sol. $\mathrm{P}=I_{\mathrm{rms}} V_{\text {rms }} \cos \theta$

$$
\begin{aligned}
& =\frac{20}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \cos \frac{\pi}{3} \\
& \Rightarrow P=50 \mathrm{~W}
\end{aligned}
$$

43. The resistance per centimeter of a meter bridge wire is $r$, with $X \Omega$ resistance in left gap. Balancing length from left end is at 40 cm with $25 \Omega$ resistance in right gap. Now the wire is replaced by another wire of $2 r$ resistance per centimeter. The new balancing length for same settings will be at
(1) 10 cm
(2) 20 cm
(3) 40 cm
(4) 80 cm

Answer (3)

Sol.

$\frac{X}{R}=\frac{l_{1}}{I_{2}}$ is independent of area

44. A small spherical ball of radius $r$, falling through a viscos medium of negligible density has terminal ' $v$ '. Another ball of the same mass but of radius $2 r$, falling through the same viscous medium will have terminal velocity
(1) $4 v$
(2) $\frac{v}{2}$
(3) $2 v$
(4) $\frac{v}{4}$

## Answer (2)

Sol. $m g=6 \pi \eta r v$
$\Rightarrow \frac{v_{1}}{v_{2}}=\frac{r_{2}}{r_{1}} \Rightarrow \frac{v}{v_{2}}=\frac{2 r}{r}$
45. Force between two point charges $q_{1}$ and $q_{2}$ placed in vacuum at ' $r$ ' cm apart is $F$. Force between them when placed in a medium having dielectric constant $K=5$ at ' $r / 5$ ' cm apart will be
(1) $F / 25$
(2) $25 F$
(3) $5 F$
(4) $F / 5$

## Answer (3)

Sol. $F=\frac{1}{4 \pi \varepsilon_{0} v} \frac{q_{1} q_{2}}{k r^{2}}$

$$
\Rightarrow \frac{F_{1}}{F_{2}}=\frac{1}{r^{2} \frac{1}{k\left(\frac{r}{5}\right)^{2}}}=5 \times \frac{1}{25}
$$

$\Rightarrow F_{2}=5 F_{1}$
46. By what percentage will the illumination of the lamp decrease if the current drops by $20 \%$ ?
(1) $26 \%$
(2) $56 \%$
(3) $36 \%$
(4) $46 \%$

Answer (3)

Sol. Brightness $\propto$ Power

$$
\begin{aligned}
& \Rightarrow P=R^{2} R \rightarrow \frac{4 i}{5} \\
& \frac{P}{P^{\prime}}=\frac{i^{2} R}{\left(\frac{4}{5} i\right)^{2} R}=\frac{25}{16} \\
& \Rightarrow \frac{16}{25} P=P^{\prime} \\
& \Rightarrow\left|\frac{P^{\prime}-P}{P} \times 100\right|=\frac{9}{25} \times 100=36 \%
\end{aligned}
$$

47. A body of mass 2 kg begins to move under the action of a time dependent force given by $\vec{F}=\left(6 t \hat{i}+6 t^{2} \hat{j}\right) N$. The power developed by the force at the time $t$ is given by
(1) $\left(9 f^{\beta}+6 t^{5}\right) W$
(2) $\left(3 t^{3}+6 t^{5}\right) W$
(3) $\left(6 t^{4}+9 t^{5}\right) W$
(4) $\left(9 t^{5}+6 \beta\right) W$

Answer (1)
Sol. $a=3 t \hat{i}+3 t^{2} \hat{j}$
$V=\frac{3 t^{2}}{2} \hat{i}+t^{3} \hat{j}$
$F=6 t \hat{i}+6 t^{2} \hat{j}$

$$
P=9 t^{3}+6 t^{5}
$$

48. If two vectors $\vec{A}$ and $\vec{B}$ having equal magnitude $R$ are inclined at an angle $\theta$, then
(1) $|\vec{A}+\vec{B}|=2 R \sin \left(\frac{\theta}{2}\right)$
(2) $|\vec{A}+\vec{B}|=2 R \cos \left(\frac{\theta}{2}\right)$
(3) $|\vec{A}-\vec{B}|=\sqrt{2} R \sin \left(\frac{\theta}{2}\right)$
(4) $|\vec{A}-\vec{B}|=2 R \cos \left(\frac{\theta}{2}\right)$

## Answer (2)

Sol. $|\vec{A}+\vec{B}|$ for $A=B=R$

$$
|\vec{A}+\vec{B}|=2 R \cos \frac{\theta}{2}
$$



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49.


The output of the given circuit diagram is

|  | $A$ | $B$ | $Y$ |
| :--- | :--- | :--- | :--- |
|  | 0 | 0 | 0 |
| (1) | 1 | 0 | 0 |
|  | 0 | 1 | 1 |
|  | 1 | 1 | 0 |

(2)

| $A$ | $B$ | $Y$ |
| :---: | :---: | :---: |
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 1 | 1 |

(3) | $A$ | $B$ | $Y$ |  |
| :---: | :---: | :---: | :---: |
| 0 | 0 | 0 |  |
|  | 1 | 0 | 1 |
|  | 0 | 1 | 1 |
|  | 1 | 1 | 0 |

(4)

| $A$ | $B$ | $Y$ |
| :---: | :---: | :---: |
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 1 | 0 |

## Answer (4)

Sol. $Y=\overline{(A+\bar{B})+(\bar{A}+B)}$
$=\overline{(A+\bar{B})} \cdot \overline{(\bar{A}+B)}$
$=(\bar{A} \cdot B) \cdot(A \cdot \bar{B})=0$
50. A light string passing over a smooth light fixed pulley connects two blocks of masses $m_{1}$ and $m_{2}$. If the acceleration of the system is $g / 8$, then the ratio of masses is

(1) $\frac{9}{7}$
(2) $\frac{8}{1}$
(3) $\frac{5}{3}$
(4) $\frac{4}{3}$

Answer (1)

Sol. $\frac{\left(m_{2}-m_{1}\right) g}{m_{2}+m_{1}}=\frac{g}{8}$

$$
\begin{aligned}
& 8 m_{2}-8 m_{1}=m_{2}+m_{1} \\
& 7 m_{2}=9 m_{1} \\
& \frac{m_{1}}{m_{2}}=\frac{7}{9}
\end{aligned}
$$

## SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. Attempt any 5 questions out of 10 . The answer to each question should be rounded-off to the nearest integer.
51. In the following circuit, the battery has an emf of 2 V and an internal resistance of $\frac{2}{3} \Omega$. The power consumption in the entire circuit is $\qquad$ W.


Answer (3)
Sol.


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

$$
P=\frac{V^{2}}{R_{4}}
$$

$$
P=\frac{2 \times 2 \times 3}{4}=3 \mathrm{~W}
$$


52. Two blocks of mass 2 kg and 4 kg are connected by a metal wire going over a smooth pulley as shown in figure. The radius of wire is $4.0 \times 10^{-5} \mathrm{~m}$ and Young's modulus of the metal is $2.0 \times 10^{11}$ $\mathrm{N} / \mathrm{m}^{2}$. The longitudinal strain developed in the wire is $\frac{1}{\alpha \pi}$. The value of $\alpha$ is $\qquad$ [Use $g=10 \mathrm{~m} / \mathrm{s}^{2}$ ]


## Answer (12)

Sol. $T=\frac{2 \times 2 \times 4 \times 10}{6}$

$$
=\frac{80}{3} \mathrm{~N}
$$

And, $\frac{\sigma}{\varepsilon}=Y$
$\Rightarrow \quad \frac{\sigma}{Y}=\varepsilon$
$\Rightarrow \frac{80}{3 \times \pi \times 16 \times 10^{-10} \times 2 \times 10^{11}}$
$=\frac{8}{96 \pi}=\frac{1}{12 \pi}$
53. The time period of simple harmonic motion of mass $M$ in the given figure is $\pi \sqrt{\frac{\alpha M}{5 k}}$, where the value of $\alpha$ is $\qquad$ .


Answer (12)

Sol. $k_{\text {eq }}=\frac{2 k}{3}+k=\frac{5 k}{3}$
$\therefore T=2 \pi \sqrt{\frac{3 M}{5 k}}=\pi \sqrt{\frac{12 M}{5 k}}$
54. Two identical spheres each of mass 2 kg and radius 50 cm are fixed at the ends of a light rod so that the separation between the centers is 150 cm . Then, moment of inertia of the system about an axis perpendicular to the rod and passing through its middle point is $\frac{x}{20} \mathrm{~kg} \mathrm{~m}^{2}$, where the value of $x$ is

## Answer (53)

Sol.

$I=\left\{\frac{2}{5} m r^{2}+m\left(\frac{I}{2}\right)^{2}\right\} \times 2$
$=\frac{4}{5} \times 2 \times \frac{1}{4}+2 \times 2 \times \frac{3}{4} \times \frac{3}{4}$
$=\frac{2}{5}+\frac{9}{4}$
$=\frac{8+45}{20}=\frac{53}{20}$
55. A body of mass ' $m$ ' is projected with a speed ' $u$ ' making an angle of $45^{\circ}$ with the ground. The angular momentum of the body about the point of projection, at the highest point is expressed as $\frac{\sqrt{2} m u^{3}}{X g}$. The value of ' $X$ ' is $\qquad$ .

## Answer (8)

Sol.

$H=\frac{u^{2} \sin ^{2} 45^{\circ}}{2 g}$
$L=m v r=m u \cos 45^{\circ} \times u^{2} \frac{1}{4 g}$

$$
=\frac{m u^{3}}{4 \sqrt{2} g}
$$



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56. The distance between charges $+q$ and $-q$ is $2 /$ and between $+2 q$ and $-2 q$ is $4 /$. The electrostatic potential at point $P$ at a distance $r$ from center $O$ is $-\alpha\left[\frac{q I}{r^{2}}\right] \times 10^{9} \mathrm{~V}$, where the value of $\alpha$ is $\qquad$ .
$\left(\right.$ Use $\left.\frac{1}{4 \pi \varepsilon_{0}}=9 \times 10^{9} \mathrm{Nm}^{2} \mathrm{C}^{-2}\right)$


Answer (27)
Sol. Assuming $r \gg 1$

$$
\begin{aligned}
P & =2 q \times 2 l-q l=3 q l \times 2 \\
V & =\frac{K P \cos \theta}{r^{3}} \\
V & =\frac{9 \times 10^{9} \times 3 q l \times \cos 120^{\circ}}{r^{3}} \times 2 \\
& =-13.5 \frac{q l}{r^{3}} \times 10^{9} \times 2 \\
& \alpha=13.5 \times 2=27
\end{aligned}
$$

57. The magnetic flux $\phi$ (in weber) linked with a closed circuit of resistance $8 \Omega$ varies with time (in seconds) as $\phi=5 t^{2}-36 t+1$. The induced current in the circuit at $t=2 \mathrm{~s}$ is $\qquad$ $A$.

## Answer (2)

Sol. $|\varepsilon|=|10 t-36|$

$$
=16 \mathrm{~V}
$$

$\therefore \quad i=\frac{16}{8}=2 \mathrm{~A}$
58. Two circular coils $P$ and $Q$ of 100 turns each have same radius of $\pi \mathrm{cm}$. The currents in $P$ and $R$ are 1 A and 2 A respectively. $P$ and $Q$ are placed with their planes mutually perpendicular with their centers coincide. The resultant magnetic field induction at the center of the coils is $\sqrt{x} \mathrm{mT}$, where $x=$ $\qquad$ . [Use $\mu_{0}=4 \pi \times 10^{-7} \mathrm{TmA}^{-1}$ ]
Answer (20)

Sol. $B_{1}=\frac{4 \pi \times 10^{-7} \times 1}{2 \times \pi \times 10^{-2}} \times 100$
$B_{1}=2 \mathrm{mT}$
$B_{2}=\frac{4 \pi \times 10^{-7} \times 2}{2 \times \pi \times 10^{-2}} \times 100=4 \mathrm{mT}$
$B=\sqrt{B_{1}^{2}+B_{2}^{2}}=\sqrt{20} \mathrm{mT}$
59. A nucleus has mass number $A_{1}$ and volume $V_{1}$. Another nucleus has mass number $A_{2}$ and Volume $V_{2}$. If relation between mass number is $A_{2}=4 A_{1}$, then $\frac{V_{2}}{V_{1}}=$ $\qquad$ .

## Answer (4)

Sol. $V \propto A$

$$
\frac{V_{1}}{V_{2}}=\frac{A_{1}}{A_{2}}=\frac{1}{4}
$$

60. Light from a point source in air falls on a convex curved surface of radius 20 cm and refractive index 1.5. If source is located at 100 cm from the convex surface, the image will be formed at $\qquad$ cm from the object.

## Answer (200)

Sol.


$$
\frac{1.5}{v}-\frac{1}{-100}=\frac{1.5-1}{20}
$$

$$
\frac{1.5}{v}=\frac{1}{40}-\frac{1}{100}
$$

$$
\frac{1.5}{v}=\frac{5-2}{200}=\frac{3}{200}
$$

$$
v=100
$$

$\therefore \quad 100+100=200 \mathrm{~cm}$


## 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 :

61. Select the option with correct property-
(1) $\left[\mathrm{Ni}(\mathrm{CO})_{4}\right]$ and $\left[\mathrm{NiCl} 4^{12-}\right.$ both Paramagnetic
(2) $\left[\mathrm{Ni}(\mathrm{CO})_{4}\right]$ and $\left[\mathrm{NiCl} 4^{12-}\right.$ both Diamagnetic
(3) $[\mathrm{NiCl} 4]^{2-}$ Diamagnetic, $\left[\mathrm{Ni}(\mathrm{CO})_{4}\right]$ Paramagnetic
(4) $\left[\mathrm{Ni}(\mathrm{CO})_{4}\right]$ Diamagnetic, $\left[\mathrm{NiCl} 4^{12-}\right.$ Paramagnetic

## Answer (4)

Sol. $\left[\mathrm{Ni}(\mathrm{CO})_{4}\right]$ is diamagnetic due to $\mathrm{d}^{10}$ configuration.
$\mathrm{Ni}^{2+}$ with no pairing will be paramagnetic due to presence of 2 unpaired electrons.
62. The four quantum numbers for the electron in the outer most orbital of potassium (atomic no. 19) are
(1) $\mathrm{n}=4, \ell=0, \mathrm{~m}=0, s=+\frac{1}{2}$
(2) $\mathrm{n}=4, \ell=2, \mathrm{~m}=-1, s=+\frac{1}{2}$
(3) $\mathrm{n}=3, \ell=0, \mathrm{~m}=1, s=+\frac{1}{2}$
(4) $\mathrm{n}=2, \ell=0, \mathrm{~m}=0, s=+\frac{1}{2}$

Answer (1)
Sol. $\mathrm{K}_{19}: 1 s^{2} 2 s^{2} 2 p^{6} 3 s^{2} 3 p^{6} 4 s^{1}$
Outermost electron is $4 s^{1}$
$\mathrm{n}=4$
I = 0
$\mathrm{m}=0$
$s=+\frac{1}{2}$
63. Identify A and B in the following reaction sequence.

(1)


(2)


(3)


(4)


Answer (1)


Sol. A :


64. Given below are two statements:

Statement I: S8 solid undergoes disproportionation reaction under alkaline conditions to from $\mathrm{S}^{2-}$ and $\mathrm{S}_{2} \mathrm{O}_{3}^{2-}$.

Statement II: $\mathrm{ClO}_{4}^{-}$can undergo disproportionation reaction under acidic condition.

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

## Answer (3)

Sol. Cl is present in highest oxidation state $(+7)$ and hence cannot undergo disproportionation reaction. Statement I is correct

Statement II is false
65. Consider the following elements.

Group ${ }_{\downarrow} \begin{aligned} & A^{\prime} B^{\prime} \rightarrow \text { Period } \\ & C^{\prime} D^{\prime}\end{aligned}$
Which of the following is/are true about $\mathrm{A}^{\prime}, \mathrm{B}^{\prime}, \mathrm{C}^{\prime}$ and $D^{\prime}$ ?
A. Order of atomic radii: $\mathrm{B}^{\prime}<\mathrm{A}^{\prime}<\mathrm{D}^{\prime}<\mathrm{C}^{\prime}$
B. Order of metallic character: $\mathrm{B}^{\prime}<\mathrm{A}^{\prime}<\mathrm{D}^{\prime}<\mathrm{C}^{\prime}$
C. Size of the element: $\mathrm{D}^{\prime}<\mathrm{C}^{\prime}<\mathrm{B}^{\prime}<\mathrm{A}^{\prime}$
D. Order of ionic radii : $\mathrm{B}^{\prime+}<\mathrm{A}^{\prime}+<\mathrm{D}^{\prime+}<\mathrm{C}^{\prime}+$

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

Answer (4)
Sol. Size of element : $\mathrm{B}^{\prime}<\mathrm{A}^{\prime}<\mathrm{D}^{\prime}<\mathrm{C}^{\prime}$
Statement $\mathrm{A}, \mathrm{B}$ and D are correct.
66. Identify major product ' P ' formed in the following reaction.

(1)

(2)

(3)

(4)


## Answer (3)

Sol. Friedel craft acylation reaction to produce benzophenone


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67. Which of the following is least ionic?
(1) $\mathrm{BaCl}_{2}$
(2) KCl
(3) $\mathrm{CoCl}_{2}$
(4) AgCl

Answer (4)
Sol. AgCl is least ionic due to pseudo inert gas configuration
68. Identify the name reaction.

(1) Gatterman-Koch Reaction
(2) Rosenmund Reduction
(3) Stephen Reaction
(4) Etard Reaction

Answer (1)
Sol. Named reaction Gattermann coch reaction is used to convert benzene directly into benzenecarbaldehyde.
69. The fragrance of flowers is due to the presence of some steam volatile organic compounds called essential oils. These are generally insoluble in water at room temperature but are miscible with water vapour in vapour phase. A suitable method for the extraction these oils from the flower is-
(1) distillation
(2) crystallisation
(3) distillation under reduced pressure
(4) steam distillation

Answer (4)
Sol. Steam distillation is used for those substances which are miscible with water vapour.
70. Given below are two statements:

Statement I: Aniline reacts with con. $\mathrm{H}_{2} \mathrm{SO}_{4}$, followed by heating at 453-473 K gives p aminobenzene sulphonic acid, which gives blood red colour in the 'Lassaigne's test'.

Statement II: In Friedel-Craft's alkylation and acylation reactions, aniline forms salt with the $\mathrm{AICl}_{3}$ catalyst. Due to this, nitrogen of aniline acquires a positive charge and acts as deactivating group.

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

## Answer (3)

Sol. Due to presence of sulphur, carbon and nitrogen compound will give blood red colour in "Lassaigne" test.

Aniline forms salt which makes it deactivating group.

Both S(I) and S(II) are correct.
71. Major product of the following reaction is -

(1)

(2)

(3)

(4)


Answer (4)

Sol.



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72. Choose the correct statements from the following
A. $\mathrm{Mn}_{2} \mathrm{O}_{7}$ is an oil at room temperature
B. $\mathrm{V}_{2} \mathrm{O}_{4}$ reacts with acid to give $\mathrm{VO}_{2}^{2+}$
C. CrO is a basic oxide
D. $\mathrm{V}_{2} \mathrm{O}_{5}$ does not react with acid

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

## Answer (4)

Sol. $\mathrm{V}_{2} \mathrm{O}_{5}$ is Amphoteric and hence can react with acid as well as base.

Statements A and C are correct.
73. Choose the correct statements from the following
A. All group 16 elements form oxides of general formula $\mathrm{EO}_{2}$ an $\mathrm{EO}_{3}$, where $\mathrm{E}=\mathrm{S}$, Se, Te and Po. Both the types of oxides are acidic in nature.
B. $\mathrm{TeO}_{2}$ is an oxidising agent while $\mathrm{SO}_{2}$ is reducing in nature.
C. The reducing property decreases from $\mathrm{H}_{2} \mathrm{~S}$ to $\mathrm{H}_{2} \mathrm{Te}$ down the group.
D. The ozone molecule contains five lone pairs of electrons.

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

## Answer (4)

Sol. (C) Reducing property increases from $\mathrm{H}_{2} \mathrm{~S}$ to $\mathrm{H}_{2} \mathrm{Te}$
(D) Ozone molecule have 6 lone pair of electrons.
$\Rightarrow$ Statements $A$ and $B$ are correct.
74. $\mathrm{A}_{(\mathrm{g})} \rightleftharpoons \mathrm{B}_{(\mathrm{g})}+\frac{\mathrm{C}}{2}(\mathrm{~g}) \quad$ The correct relationship between $K_{p}, \alpha$ and equilibrium pressure $P$ is
(1) $K_{P}=\frac{\alpha^{1 / 22} \mathrm{P}^{1 / 2}}{(2+\alpha)^{1 / 2}}$
(2) $\mathrm{K}_{\mathrm{P}}=\frac{\alpha^{1 / 2 \mathrm{P}^{3 / 2}}}{(2+\alpha)^{3 / 2}}$
(3) $K_{P}=\frac{\alpha^{3 / 2 P^{1 / 2}}}{(2+\alpha)^{1 / 2}(1-\alpha)}$
(4) $K_{P}=\frac{\alpha^{1 / 2 P^{1 / 2}}}{(2+\alpha)^{3 / 2}}$

## Answer (3)

Sol. $A(g) \rightleftharpoons B(g)+\frac{C}{2}(g)$
$(1-\alpha) \quad \alpha \quad \frac{\alpha}{2}$
$\mathrm{K}_{\mathrm{p}}=\mathrm{K}_{\mathrm{x}}\left(\mathrm{P}_{\text {total }}\right)^{1 / 2}$
$K_{p}=\frac{\alpha^{\frac{3}{2}}}{(2+\alpha)^{1 / 2}(1-\alpha)}(P)^{1 / 2}$
Option (3) is correct.
75. The correct order of reactivity in electrophilic substitution reaction of the following compound is:

(1) A $>$ B $>$ C $>$ D
(2) B $>$ A $>$ C $>$ D
(3) D $>$ C $>$ B $>$ A
(4) B $>$ C $>$ A $>$ D

Answer (2)


Sol. Rate $\propto$ electron density on benzene ring.
Correct order is $\mathrm{B}>\mathrm{A}>\mathrm{C}>\mathrm{D}$
Option (2) is correct.
76. A sample of $\mathrm{CaCO}_{3}$ and $\mathrm{MgCO}_{3}$ weighed 2.21 g is ignited to constant weight of 1.152 g . The composition of mixture is:
(Given molar mass in $\mathrm{g} \mathrm{mol}^{-1} \mathrm{CaCO}_{3}$ : 100 , $\mathrm{MgCO}_{3}$ : 84)
(1) $1.187 \mathrm{~g} \mathrm{CaCO}_{3}+1.023 \mathrm{~g} \mathrm{MgCO}_{3}$
(2) $1.187 \mathrm{~g} \mathrm{CaCO}_{3}+1.187 \mathrm{~g} \mathrm{MgCO}_{3}$
(3) $1.023 \mathrm{~g} \mathrm{CaCO}_{3}+1.187 \mathrm{~g} \mathrm{MgCO}_{3}$
(4) $1.023 \mathrm{~g} \mathrm{CaCO}_{3}+1.023 \mathrm{~g} \mathrm{MgCO}_{3}$

## Answer (1)

Sol. Assume mass of $\mathrm{CaCO}_{3}=x \mathrm{gm}$
Mass of $\mathrm{MgCO}_{3}=(2.21-x) \mathrm{gm}$
$\mathrm{CaCO}_{3} \xrightarrow{\Delta} \mathrm{CaO}+\mathrm{CO}_{2} \uparrow$
$\mathrm{MgCO}_{3} \xrightarrow{\Delta} \mathrm{MgO}+\mathrm{CO}_{2} \uparrow$
(Mass of CaO$)+($ Mass of MgO$)=1.152 \mathrm{gm}$
$\left(\frac{x}{100} \times 56\right)+\left(\frac{2.21-x}{84}\right) \times 40=1.152$
$x=1.187 \mathrm{gm}$
$\Rightarrow \mathrm{CaCO}_{3}=1.187 \mathrm{gm}$
$\Rightarrow \mathrm{MgCO}_{3}=1.023 \mathrm{gm}$
77. Identify structure of 2,3-dibromo-1-phenylpentane.
(1)

(2)

(3)

(4)


## Answer (2)

Sol. 2-3-dibromo-1-phenylpentane

78. The azo-dye $(Y)$ formed in the following reaction is Sulphanilic acid $+\mathrm{NaNO}_{2}+\mathrm{CH}_{3} \mathrm{COOH} \rightarrow \mathrm{X}$.

X +


(1)

(2)

(3)

(4)


Answer (3)


Sol. Coupling reaction at para-position of $\mathrm{NH}_{2}$ will take place.
Option (3) is correct.
79. Match List I with List II

|  | List I <br> (Complex ion) |  | List II <br> (Electronic <br> Configuration) |
| :--- | :--- | :--- | :--- |
| A. | $\left[\mathrm{Cr}\left(\mathrm{H}_{2} \mathrm{O}_{6}\right)\right]^{3+}$ | I. | $\mathrm{t}_{2 \mathrm{~g}}{ }^{2} \mathrm{e}_{\mathrm{g}}^{0}$ |
| B. | $\left[\mathrm{Fe}\left(\mathrm{H}_{2} \mathrm{O}\right)_{6}\right]^{3+}$ | II. | $\mathrm{t}_{2 g}{ }^{3} \mathrm{e}_{\mathrm{g}}^{0}$ |
| C. | $\left[\mathrm{Ni}\left(\mathrm{H}_{2} \mathrm{O}\right)_{6}\right]^{2+}$ | III. | $\mathrm{t}_{2 \mathrm{~g}}{ }^{3} \mathrm{e}_{\mathrm{g}}^{2}$ |
| D. | $\left[\mathrm{V}\left(\mathrm{H}_{2} \mathrm{O}\right)_{6}\right]^{3+}$ | IV. | $\mathrm{t}_{2 g}{ }^{6} \mathrm{e}_{\mathrm{g}}^{2}$ |

Choose the correct answer from the option given below:
(1) A-IV, B-I, C-II, D-III
(2) A-III, B-II, C-IV, D-I
(3) A-II, B-III, C-IV, D-I
(4) A-IV, B-III, C-I, D-II

Answer (3)
Sol. A
$\mathrm{Cr}^{3+}$ :
$t_{29}^{3} e_{g}^{0}$
B
$\mathrm{Fe}^{3+}$
$t_{2 g}^{3} e_{g}^{2}$
C : $\quad \mathrm{Ni}^{2+}$
$t_{29}^{6} e_{g}^{2}$
D
$\mathrm{V}^{3+} \quad:$
$\mathrm{t}_{2 \mathrm{~g}}^{2} \mathrm{e}_{\mathrm{g}}^{0}$
80. Given below are two statements:

Statement I: Group 13 trivalent halides get easily hydrolyzed by water due to their covalent nature.
Statement II: $\mathrm{AlCl}_{3}$ upon hydrolysis in acidified aqueous solution forms octahedral $\left[\mathrm{Al}\left(\mathrm{H}_{2} \mathrm{O}_{6}\right)^{3+}\right]$ ion. In the light of the above statements, choose the correct answer from the options given below:
(1) Both statement I and statement II are true
(2) Statement I is true but statement II is false
(3) Statement I is false but statement II is true
(4) Both statement I and statement II are false

Answer (1)
Sol. Al can expand its octet due to presence of vacant d-orbital.
Statement I and Statement II both are correct.

## SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. Attempt any 5 questions out of 10 . The answer to each question should be rounded-off to the nearest integer.
81. The molarity of 1 L orthophosphoric acid $\left(\mathrm{H}_{3} \mathrm{PO}_{4}\right)$ having $70 \%$ purity by weight (specific gravity $1.54 \mathrm{~g} \mathrm{~cm}^{-3}$ ) is $\qquad$ M.
(Molar mass of $\mathrm{H}_{3} \mathrm{PO}_{4}=98 \mathrm{~g} \mathrm{~mol}^{-1}$ )

## Answer (11)

Sol. Mass of solution $=1540 \mathrm{gm}$
Mass of $\mathrm{H}_{3} \mathrm{PO}_{4}=1540 \times \frac{70}{100}=1078 \mathrm{gm}$
Moles of solute $=\frac{1078}{98}=11$
82. A compound (x) with molar mass $108 \mathrm{~g} \mathrm{~mol}^{-1}$ undergoes acetylation to give product with molar mass $192 \mathrm{~g} \mathrm{~mol}^{-1}$. The number of amino groups in the compound ( x ) is $\qquad$ .

Answer (2)
Sol. Number of amino groups $=\left(\frac{192-108}{42}\right)=2$
83. $r=k[A]$ for a reaction, $50 \%$ of $A$ is decomposed in 120 minutes. The time taken for $90 \%$ decomposition of $A$ is $\qquad$ minutes.

## Answer (399)

Sol. too $^{2}=\frac{2.303}{\mathrm{~K}} \log 10=\frac{2.303}{\mathrm{~K}}$
$t_{50}=\frac{2.303}{K} \log 2=120$


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$\frac{2.303}{K}=\frac{120}{\log 2}$
$t_{90}=\frac{120}{0.3010}=398.67$
Nearest integer $=399$
84. A diatomic molecule has a dipole moment of 1.2 D. If the bond distance is $1 \AA$, then fractional charge on each atom is $\qquad$ $\times 10^{-1}$ esu.
(Given $1 \mathrm{D}=10^{-18}$ esucm)

## Answer (1.2 $\times 10^{-9}$ )

Sol. Dipole moment : 1.2 D

$$
=1.2 \times 10^{-18} \mathrm{esucm}
$$

$\mu=$ q. $d$
$1.2 \times 10^{-18}=(q) \times 10^{-8}$
$\mathrm{q}=1.2 \times 10^{-10} \mathrm{esu}$
$\mathrm{q}=1.2 \times 10^{-9} \times 10^{-1} \mathrm{esu}$
85. The values of conductivity of some materials at $298.15 \mathrm{~K} \mathrm{in}_{\mathrm{Sm}}{ }^{-1}$ are $2.1 \times 10^{3}, 1.0 \times 10^{-16}, 1.2 \times$ $10,3.91,1.5 \times 10^{-2}, 1 \times 10^{-7}, 1.0 \times 10^{3}$. The number of conductors among the materials is $\qquad$ -

## Answer (4)

Sol. Conductors with conductivity
$2.1 \times 10^{3}$ : Sodium
$1.2 \times 10$ : Graphite
$3.91: 0.1 \mathrm{M} \mathrm{HCl}$
$1.0 \times 10^{3}$ : Iron
[Ref. - NCERT]
86. If 5 moles of an ideal gas expands from $10 L$ to a volume of 100 L at 300 K under isothermal and reversible condition then work, w , is -x J . The value of $x$ is $\qquad$ .
(Given $\mathrm{R}=8.314 \mathrm{~J} \mathrm{~K}^{-1} \mathrm{~mol}^{-1}$ )
Answer (28721)

Sol. W = -2.303(5)(8.314)(300) $\log 10$
$=-28720.713 \mathrm{~J}$
$\mathrm{x}=28720.713$
Nearest integer $=28721$
87. In the reaction of potassium dichromate, potassium chloride and sulfuric acid (conc.), the oxidation state of the chromium in the product is (+) $\qquad$ .

## Answer (6)

Sol. Product is $\mathrm{Cr}_{2} \mathrm{O}_{2} \mathrm{Cl}_{2}$
Oxidation state of Cr is +6 .
88. Number of moles of $\mathrm{H}^{+}$ions required by 1 mole of $\mathrm{MnO}_{4}^{-}$to oxidise oxalate ion to $\mathrm{CO}_{2}$ is $\qquad$ .

## Answer (8)

Sol. Balanced reaction:

$$
\begin{aligned}
16 \mathrm{H}^{+}+ & 2 \mathrm{MnO}_{4}^{-}+5 \mathrm{C}_{2} \mathrm{O}_{4}^{2-} \\
& \longrightarrow 10 \mathrm{CO}_{2}+2 \mathrm{Mn}^{2+}+8 \mathrm{H}_{2} \mathrm{O}
\end{aligned}
$$

Moles of $\mathrm{H}^{+}$required $=8$
89. Number of isomeric products formed by monochlorination of 2-methylbutane in presence of sunlight is $\qquad$ .
Answer (6)
Sol.


4 structural isomers are possible out of which 2 are optically active.

Total 6 isomers are possible
90. From the vitamins $\mathrm{A}, \mathrm{B}_{1}, \mathrm{~B}_{6}, \mathrm{~B}_{12}, \mathrm{C}, \mathrm{D}, \mathrm{E}$ and K , the number of vitamins that can be stored in our body is $\qquad$ .

## Answer (5)

Sol. Following vitamins can be stored in human body Vitamin A, D, E, K, B12


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