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## 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 $\mathbf{+ 4}$ marks 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 Ajay will not appear in JEE exam with probability $p=\frac{2}{7}$, while both Ajay and Vijay will appear in the exam with probability $q=\frac{1}{5}$. Then the probability, that Ajay will appear in the exam and Vijay will not appear is
(1) $\frac{9}{35}$
(2) $\frac{24}{35}$
(3) $\frac{3}{35}$
(4) $\frac{18}{35}$

## Answer (4)

Sol. $P(A \cap B)=\frac{1}{5}$

$$
\begin{aligned}
& P\left(A^{\prime}\right)=\frac{2}{7} \\
& \therefore \quad P(A)=1-\frac{2}{7}=\frac{5}{7} \\
& P\left(A \cap B^{\prime}\right)=P(A)-P(A \cap B) \\
& =\frac{5}{7}-\frac{1}{5}=\frac{18}{35}
\end{aligned}
$$

2. If the domain of the function $f(x)=\frac{\sqrt{x^{2}-25}}{\left(4-x^{2}\right)}+\log _{10}\left(x^{2}+2 x-15\right)$ is $(-\infty, \alpha) \cup$ $[\beta, \infty)$, then $\alpha^{2}+\beta^{3}$ is equal to
(1) 175
(2) 150
(3) 125
(4) 140

Answer (2)

Sol. $f(x)=\frac{\sqrt{x^{2}-25}}{\left(4-x^{2}\right)}+\log _{10}\left(x^{2}+2 x-15\right)$

$$
\begin{align*}
& x^{2}-25 \geq 0 \\
& \Rightarrow \quad x \in(-\infty,-5] \cup[5, \infty)  \tag{I}\\
& \quad 4-x^{2} \neq 0 \\
& \Rightarrow \quad x \neq \pm 2  \tag{II}\\
& x^{2}+2 x-15>0 \\
& (x-3)(x+5)>0 \\
& x \in(-\infty,-5) \cup(3, \infty) \tag{III}
\end{align*}
$$

From (I), (II) and (III)
$x \in(-\infty,-5) \cup[5, \infty)$
$\therefore \quad \alpha=-5, \beta=5$
$\alpha^{2}+\beta^{3}=(-5)^{2}+(5)^{3}=150$
3. Consider a $\triangle A B C$ where $A(1,3,2), B(-2,8,0)$ and $C(3,6,7)$. If the angle bisector $\angle B A C$ meets the line $B C$ at $D$, then the length of the projection of the vector $\overrightarrow{A D}$ on the vector $\overrightarrow{A C}$ is
(1) $\frac{37}{2 \sqrt{38}}$
(2) $\frac{39}{2 \sqrt{38}}$
(3) $\sqrt{19}$
(4) $\frac{\sqrt{38}}{2}$

Answer (1)
Sol.

$D$ divides $B C$ in ratio 1:1
$D:\left(\frac{1}{2}, 7, \frac{7}{2}\right)$


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$\overrightarrow{A D}=\left(\frac{1}{2}-1\right) \hat{i}+(7-3) \hat{j}+\left(\frac{7}{2}-2\right) \hat{k}$
$=-\frac{1}{2} \hat{i}+4 \hat{j}+\frac{3}{2} \hat{k}$
$\overrightarrow{A C}=2 \hat{i}+3 \hat{j}+5 \hat{k}$
Projection of $\overrightarrow{A D}$ on $\overrightarrow{A C}$
$=\frac{-1+12+\frac{15}{2}}{\sqrt{4+9+25}}=\frac{37}{2 \sqrt{38}}$
4. Let $S_{n}$ denote the sum of the first $n$ terms of an arithmetic progression. If $S_{10}=390$ and the ratio of the tenth the fifth terms is $15: 7$, then $S_{15}-S_{5}$ is equal to
(1) 890
(2) 690
(3) 790
(4) 800

Answer (3)
Sol. $S_{10}=390$
$\frac{a_{10}}{a_{5}}=\frac{15}{7}$
$\frac{a+9 d}{a+4 d}=\frac{15}{7}$
$7 a+63 d=15 a+60 d$
$8 a-3 d=0$
also, $S_{10}=390$
$5[2 a+9 d]=390$
$2 a+9 d=78$
From equation (1) \& (2)
$d=8$
$\Rightarrow a=3$
So, $S_{15}-S_{5}=\frac{15}{2}[2 a+14 d]-\frac{5}{2}[2 a+4 d]$
$=5[2 a+19 d]$
Putting values of $a$ and $d$ in above equation
$S_{15}-S_{5}=5[2(3)+19(8)]$
$S_{15}-S_{5}=790$
5. Let $\alpha$ and $\beta$ be the roots the equation $p x^{2}+q x-r=0$, where $p \neq 0$. If $p, q$ and $r$ be the consecutive terms of a non-constant G.P. and $\frac{1}{\alpha}+\frac{1}{\beta}=\frac{3}{4}$, then the value of $(\alpha-\beta)^{2}$ is
(1) $\frac{80}{9}$
(2) 9
(3) 8
(4) $\frac{20}{3}$

Answer (1)
Sol. Given: $p x^{2}+q x-r=0$
Let $p=\frac{a}{r_{1}}, q=a, r=a r_{1}$
and $\frac{1}{\alpha}+\frac{1}{\beta}=\frac{3}{4}$
$\Rightarrow \frac{\alpha+\beta}{\alpha \beta}=\frac{3}{4}$
$\Rightarrow \frac{-\frac{q}{p}}{-\frac{r}{p}}=\frac{3}{4}$
$\Rightarrow \quad \frac{q}{r}=\frac{3}{4}$
$\Rightarrow \frac{1}{r_{1}}=\frac{3}{4}$
$\Rightarrow \quad r_{1}=\frac{4}{3}$
$(\alpha-\beta)^{2}=(\alpha+\beta)^{2}-4 \alpha \beta$

$$
\begin{aligned}
& =\left(\frac{-q}{p}\right)^{2}-4\left(\frac{-r}{p}\right) \\
& =\frac{q^{2}}{p^{2}}+\frac{4 r}{p} \\
& =r_{1}^{2}+4 r_{1}^{2}=5 r_{1}^{2} \\
& =5\left(\frac{4}{3}\right)^{2}=\frac{80}{9}
\end{aligned}
$$



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6. Let the locus of the midpoints of the chords of the circle $x^{2}+(y-1)^{2}=1$ drawn from the origin intersect the line $x+y=1$ at $P$ and $Q$. Then, the length of $P Q$ is
(1) $\sqrt{2}$
(2) 1
(3) $\frac{1}{\sqrt{2}}$
(4) $\frac{1}{2}$

## Answer (3)

Sol. Let mid-point is $(x, y)$
$x^{2}+y^{2}-2 y=0$
$x x_{1}+y y_{1}-\left(y+y_{1}\right)=x_{1}^{2}+y_{1}^{2}-2 y_{1}$
It is passing through origin
So, $0+0-\left(0+y_{1}\right)=x_{1}^{2}+y_{1}^{2}-2 y_{1}$
$\Rightarrow \quad-y_{1}=x_{1}^{2}+y_{1}^{2}-2 y_{1}$
$\Rightarrow \quad x_{1}^{2}+y_{1}^{2}-y_{1}=0$
$x^{2}+y^{2}-y=0$
$\because$ It intersects the line $x+y=1$
So put $x=1-y$ in equation (1)
$(1-y)^{2}+y^{2}-y=0$
$2 y^{2}-3 y+1=0$
$\Rightarrow(y-1)(2 y-1)=0$
$\Rightarrow y=1, \frac{1}{2}$
$\therefore \quad P(0,1)$ and $Q\left(\frac{1}{2}, \frac{1}{2}\right)$
So, $P Q=\sqrt{\left(\frac{1}{2}-0\right)^{2}+\left(\frac{1}{2}-1\right)^{2}}=\frac{1}{\sqrt{2}}$
7. If the mirror image of the point $P(3,4,9)$ in the line $\frac{x-1}{3}=\frac{y+1}{2}=\frac{z-2}{1}$ is $(\alpha, \beta, \gamma)$, then $14(\alpha+\beta+\gamma)$ is
(1) 138
(2) 102
(3) 132
(4) 108

## Answer (4)

Sol. $P(3,4,9)$
$\frac{x-1}{3}=\frac{y+1}{2}=\frac{z-2}{1}=\lambda$
Any point on line
$Q(3 \lambda+1,2 \lambda-1, \lambda+2)$
$P Q<3,2,1>=0$
$<3 \lambda-2,2 \lambda-5, \lambda-7><3,2,1>=0$
$9 \lambda-6+4 \lambda-10+\lambda-7=0$
$14 \lambda-23=0$
$\lambda=\frac{23}{14}$
$\therefore Q\left(\frac{83}{14}, \frac{32}{14}, \frac{51}{14}\right)$
$\stackrel{Q\left(\frac{83}{14}, \frac{32}{14}, \frac{51}{14}\right)}{P(3,4,9)} \longrightarrow P(\alpha, \beta, \gamma)$
$\frac{3+\alpha_{1}}{2}=\frac{83}{14} \Rightarrow x_{1}=\frac{62}{7}$
$\frac{4+\beta_{1}}{2}=\frac{32}{14} \Rightarrow y_{1}=\frac{4}{7}$
$\frac{9+\gamma_{1}}{2}=\frac{51}{14} \Rightarrow z_{1}=-\frac{12}{7}$
Now, $14(\alpha+\beta+\gamma)=14\left(\frac{62+4-12}{7}\right)=108$
8. Let $m$ and $n$ be the coefficients of seventh and thirteenth terms respectively in the expansion of $\left(\frac{1}{3} x^{\frac{1}{3}}+\frac{1}{2 x^{\frac{2}{3}}}\right)^{18}$. Then $\left(\frac{n}{m}\right)^{\frac{1}{3}}$ is
(1) $\frac{4}{9}$
(2) $\frac{1}{4}$
(3) $\frac{9}{4}$
(4) $\frac{1}{9}$

Answer (3)


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Sol. $T_{7}=m={ }^{18} C_{6}\left(\frac{1}{3}\right)^{12}\left(\frac{1}{2}\right)^{6}$

$$
\begin{aligned}
& T_{13}=n={ }^{18} C_{12}\left(\frac{1}{3}\right)^{6}\left(\frac{1}{2}\right)^{12} \\
& \begin{aligned}
\left(\frac{m}{n}\right)^{\frac{1}{3}} & =\left(\frac{{ }^{18} C_{6}\left(\frac{1}{3}\right)^{12}\left(\frac{1}{2}\right)^{6}}{{ }^{18} C_{12}\left(\frac{1}{3}\right)^{6}\left(\frac{1}{2}\right)^{12}}\right)^{\frac{1}{3}} \\
& =\left(\frac{\left(\frac{1}{3}\right)^{6}}{\left(\frac{1}{2}\right)^{6}}\right)^{\frac{1}{3}}=\left(\left(\frac{2}{3}\right)^{6}\right)^{\frac{1}{3}}=\frac{4}{9} \\
\therefore\left(\frac{n}{m}\right)^{\frac{1}{3}} & =\frac{9}{4}
\end{aligned}
\end{aligned}
$$

9. If $z$ is a complex number such that $|z| \geq 1$, then the minimum value of $\left|z+\frac{1}{2}(3+4 i)\right|$ is
(1) 3
(2) 2
(3) $\frac{3}{2}$
(4) $\frac{5}{2}$

## Answer (3)

Sol. $|z| \geq 1$

$$
\begin{aligned}
\left|z+\frac{1}{2}(3+4 i)\right| & \left.\geq|z|-\left|\frac{3}{2}+2 i\right| \right\rvert\, \\
& \geq\left|1-\sqrt{\frac{9}{4}+4}\right| \geq\left|1-\sqrt{\frac{9+16}{4}}\right| \\
& \geq\left|1-\frac{5}{2}\right| \geq\left|\frac{2-5}{2}\right| \\
& \geq \frac{3}{2}
\end{aligned}
$$

$\therefore$ Option (3) is correct
10. Let the system of equations $x+2 y+3 z=5$, $2 x+3 y+z=9,4 x+3 y+\lambda z=\mu$ have infinite number of solutions. Then $\lambda+2 \mu$ is equal to
(1) 15
(2) 28
(3) 22
(4) 17

Answer (4)
Sol. Given $x+2 y+3 z=5$
$2 x+3 y+z=9$
$4 x+3 y+\lambda z=\mu$
$\Delta=\left|\begin{array}{ccc}1 & 2 & 3 \\ 2 & 3 & 1 \\ 4 & 3 & \lambda\end{array}\right|$
$\Delta=1(3 \lambda-3)-2(2 \lambda-4)+3(6-12)$
$\Delta=3 \lambda-3-4 \lambda+8+18-36$
$\Delta=-\lambda-13$
$\Delta=0 \quad \Rightarrow \Delta=-13$
$\Delta_{3}=\left|\begin{array}{lll}1 & 2 & 5 \\ 2 & 3 & 9 \\ 4 & 3 & \mu\end{array}\right|$

$$
\begin{aligned}
& =1(3 \mu-27)-2(2 \mu-36)+5(6-12) \\
& =3 \mu-27-4 \mu+72+30-60 \\
& =-\mu+15 \Rightarrow \mu=15
\end{aligned}
$$

$\therefore \lambda+2 \mu=-13+30=17$
Option (4) is correct.
11. Let $P$ be a point on the ellipse $\frac{x^{2}}{9}+\frac{y^{2}}{4}=1$. Let the line passing through $P$ and parallel to $y$-axis meet the circle $x^{2}+y^{2}=9$ at point $Q$ such that $P$ and $Q$ are on the same side of the $x$-axis. Then, the eccentricity of the locus of the point $R$ on $P Q$ such that $P R: R Q=4: 3$ as $P$ moves on the ellipse, is
(1) $\frac{\sqrt{139}}{23}$
(2) $\frac{\sqrt{13}}{7}$
(3) $\frac{11}{19}$
(4) $\frac{13}{21}$

Answer (2)


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Sol.

$h=\frac{12 \cos \theta+9 \cos \theta}{7}\left(\frac{7 h}{21}\right)^{2}+\left(\frac{7 k}{18}\right)^{2}=1$
$k=\frac{12 \sin \theta+6 \sin \theta}{7}$
$e^{2}=1-\frac{18^{2}}{21^{2}}$
$e^{2}=\frac{21^{2}-18^{2}}{21^{2}}$
$e^{2}=\frac{117}{21^{2}}$
$e^{2}=\frac{\sqrt{117}}{21}=\frac{\sqrt{13}}{7}$
12. Consider the relations $R_{1}$ and $R_{2}$ defined as $a R_{1} b \Leftrightarrow a^{2}+b^{2}=1$ for all $a, b \in \mathbf{R}$ and $(a, b) R_{2}$ $(c, d) \Leftrightarrow a+d=b+c$ for all $(a, b),(c, d) \in \mathbf{N} \times \mathbf{N}$. Then
(1) Neither $R_{1}$ nor $R_{2}$ is an equivalence relation
(2) Only $R_{2}$ is an equivalence relation
(3) $R_{1}$ and $R_{2}$ both are equivalence relations
(4) Only $R_{1}$ is an equivalence relation

## Answer (2)

Sol. $a \boldsymbol{R} b \Leftrightarrow a^{2}+b^{2}=1$
For reflexive ( $a R a$ ) $\forall a \in I R$
If $a \boldsymbol{R}$ a
$\Rightarrow a^{2}+a^{2}=1$
$\Rightarrow 2 a^{2}=1$
$\Rightarrow a \Rightarrow \pm \frac{1}{\sqrt{2}}$
So, $R_{1}$ is not reflexive as (a, a) $\notin R \forall a \in \mathbb{R}$
$(a, b) R_{2}(c, d) \Rightarrow a+d=b+c$
For reflexive
$(a, b) R_{2}(a, b) \forall(a, b) \in I N \times I N$
$a+b=b+a$
$[(a, b),(a, b)] \in I R_{2} \forall(a, b) \in I N \times I N$
So $R_{2}$ is reflexive relation
For symmetric.
If $(a, b) R_{2}(c, d)$
Then ( $c, d$ ) $R_{2}(a, b)$
So $(a, b) R_{2}(c, d) \Rightarrow a+d=b+c$
For $(c, d) R_{2}(a, b) \Rightarrow c+b=a+d$
So $R_{2}$ is symmetric
For transitive:
If $(a, b) R_{2}(c, d)$ and ( $\left.c, d\right) R_{2}(e, f)$
Then $(a, b) R_{2}(e, f)$
$(a, b) R_{2}(c, d) \Rightarrow a+d=b+c$
(c, d) $R_{2}(e, f) \Rightarrow c+f=e+d$
Add equation (i) and (ii)
$a+d+c+f=b+c+e+d$
$\Rightarrow a+f=b+e$
$\Rightarrow(a, b) R_{2}(e, f)$
So $R_{2}$ is transitive
Only $R_{2}$ is equivalence relation.
13. If $\int_{0}^{\frac{\pi}{3}} \cos ^{4} x d x=a \pi+b \sqrt{3}$, where $a$ and $b$ are rational numbers, then $9 a+8 b$ is equal to
(1) 3
(2) 1
(3) 2
(4) $\frac{3}{2}$

Answer (3)


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Sol. $\int_{0}^{\frac{\pi}{3}} \cos ^{4} x d x$

$$
\begin{aligned}
& =\frac{1}{4} \int_{0}^{\frac{\pi}{3}}(1+\cos 2 x)^{2} d x \\
& =\frac{1}{4} \int_{0}^{\frac{\pi}{3}}\left(1+\cos ^{2} 2 x+2 \cos 2 x\right) d x
\end{aligned}
$$

$$
=\frac{1}{4}\left[\left(\frac{\pi}{3}\right)+\int_{0}^{\frac{\pi}{3}}\left(\frac{1+\cos 4 x}{2}\right) d x+\left.\frac{2 \sin 2 x}{2}\right|_{0} ^{\frac{\pi}{3}}\right]
$$

$$
=\frac{1}{4}\left[\left(\frac{\pi}{3}\right)+\left.\frac{1}{2}\left(x+\frac{\sin 4 x}{4}\right)\right|_{0} ^{\frac{\pi}{3}}+\left(\sin \frac{2 \pi}{3}\right)\right]
$$

$$
=\frac{1}{4}\left[\frac{\pi}{3}+\frac{1}{2}\left(\frac{\pi}{3}+\frac{1}{4}\left(\sin \frac{4 \pi}{3}\right)\right)+\frac{\sqrt{3}}{2}\right]
$$

$$
=\frac{1}{4}\left[\frac{\pi}{3}+\frac{\pi}{6}+\frac{1}{8}\left(\frac{-\sqrt{3}}{2}\right)+\frac{\sqrt{3}}{2}\right]
$$

$$
=\frac{\pi}{8}+\frac{7 \sqrt{3}}{64}=a \pi+b \sqrt{3}
$$

$$
\Rightarrow \quad a=\frac{1}{8}, b=\frac{7}{64}
$$

$$
9 a+8 b=2
$$

14. Let $f(x)=\left\{\begin{array}{cc}x-1, & x \text { is even } \\ 2 x, & x \text { is odd }\end{array} \quad x \in N\right.$. If for some $a \in N, f(f(f(a)))=21$, then $\lim _{x \rightarrow a^{-}}\left\{\frac{|x|^{3}}{a}-\left[\frac{x}{a}\right]\right\}$, where [ $t$ ] denotes the greatest integer less than or equal to $t$, is equal to
(1) 225
(2) 144
(3) 169
(4) 121

Answer (2)

Sol. $f(x)=\left\{\begin{array}{cc}x-1 & x \text { is even } \\ 2 x & x \text { is odd }\end{array} \quad x \in N\right.$
Let $a$ is odd
$\Rightarrow f(a)=2 a$
$\Rightarrow f(f(a))=2 a-1$
$\Rightarrow f(f(f(a)))=2(2 a-1)$
$2(2 a-1)=21$ Not possible for any $a \in N$
Let $a$ is even
$\Rightarrow f(a)=a-1$
$\Rightarrow f(f(a))=2(a-1)$
$\Rightarrow f(f(f(a)))=2(a-1)-1=2 a-3$
$2 a-3=21 \quad \Rightarrow a=12$
Now, $\lim _{x \rightarrow 12^{-}}\left(\frac{|x|^{3}}{12}-\left[\frac{x}{12}\right]\right)=144$
15. Let $P$ and $Q$ be the points on the line $\frac{x+3}{8}=\frac{y-4}{2}=\frac{z+1}{2}$ which are at a distance of 6 units from the point $R(1,2,3)$. If the centroid of the triangle $P Q R$ is $(\alpha, \beta, \gamma)$, then $\alpha^{2}+\beta^{2}+\gamma^{2}$ is
(1) 26
(2) 18
(3) 24
(4) 36

Answer (2)
Sol. Any point on line $\frac{x+3}{8}=\frac{y-4}{2}=\frac{z+1}{2}$
can be taken as $(8 \lambda-3,2 \lambda+4,2 \lambda-1)$
If at a distance of 6 units from $R(1,2,3)$
$\Rightarrow(8 \lambda-3-1)^{2}+(2 \lambda+4-2)^{2}+(2 \lambda-1-3)^{2}=36$
$\Rightarrow \lambda^{2}-\lambda=0$ \{on simplification $\}$
$\Rightarrow \lambda=0, \lambda=1$
Here $P \& Q$ are $(-3,4,-1)$ and $(5,6,1)$
Centroid of $\triangle P Q R$

$$
\begin{aligned}
& (\alpha, \beta, \gamma) \equiv\left(\frac{5-3+1}{3}, \frac{6+4+2}{3}, \frac{1-1+3}{3}\right) \\
& \Rightarrow \alpha=1, \beta=4, \gamma=1 \\
& \Rightarrow \alpha^{2}+\beta^{2}+\gamma^{2}=18
\end{aligned}
$$



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16. Let $f(x)=\left|2 x^{2}+5\right| x|-3|, x \in R$. If $m$ and $n$ denote the number of points where $f$ is not continuous and not differentiable respectively, then $m+n$ is equal to
(1) 3
(2) 5
(3) 0
(4) 2

## Answer (1)

Sol. $f(x)=\left|2 x^{2}+5\right| x|-3|$


Now $f(x)$ is continuous $\forall x \in R$
but non- differentiable at $x=\frac{-1}{2}, \frac{1}{2}, 0$
$\therefore \quad m=0$

$$
n=3
$$

$m+n=3$
17. Consider 10 observations $x_{1}, x_{2}, \ldots, x_{10}$ such that $\sum_{i=1}^{10}\left(x_{i}-\alpha\right)=2 \sum_{i=1}^{10}\left(x_{i}-\beta\right)^{2}=40$, where $\alpha, \beta$ are positive integers. Let the mean and the variance of the observations be $\frac{6}{5}$ and $\frac{84}{25}$ respectively. Then $\frac{\beta}{\alpha}$ is equal to :
(1) 1
(2) $\frac{3}{2}$
(3) 2
(4) $\frac{5}{2}$

Answer (3)

Sol. We have given $\bar{x}($ mean $)=\frac{6}{5}$

$$
\begin{aligned}
& \text { Variance }=\frac{84}{25} \\
& \sum_{i=1}^{10}\left(x_{i}-\alpha\right)=2 \\
& \Rightarrow x_{1}+x_{2}+\ldots+x_{10}-10 \alpha=2 \\
& \Rightarrow \frac{x_{1}+x_{2}+\ldots+x_{10}}{10}-\alpha=\frac{2}{10} \\
& \Rightarrow \frac{6}{5}-\alpha=\frac{2}{10} \\
& \Rightarrow \alpha=1
\end{aligned}
$$

$$
\text { and } \sum_{i=1}^{10}\left(x_{i}-\beta\right)^{2}=40
$$

$$
\left(x_{1}-\beta\right)^{2}+\left(x_{2}-\beta\right)^{2}+\ldots+\left(x_{10}-\beta\right)^{2}=40
$$

$$
x_{1}^{2}+x_{2}^{2}+\ldots+x_{10}^{2}+10 \beta^{2}-2 \beta\left(x_{1}+x_{2}+\ldots+x_{10}\right)=40
$$

$$
\Rightarrow \frac{x_{1}^{2}+x_{2}^{2}+\ldots+x_{10}^{2}}{10}+\beta^{2}-\frac{2 \beta\left(x_{1}+x_{2}+\ldots+x_{10}\right)}{10}=4
$$

$$
\Rightarrow \frac{x_{1}^{2}+x_{2}^{2}+\ldots+x_{10}^{2}}{10}-\frac{36}{25}+\frac{36}{25}+\beta^{2}-2 \beta \times \frac{6}{5}=4
$$

$$
\left[\text { Variance }=\frac{\sum_{i=1}^{n} x_{i}^{2}}{n}-(\bar{x})^{2}\right]
$$

$$
\Rightarrow \frac{84}{25}+\frac{36}{25}+\beta^{2}-\frac{12 \beta}{5}-4=0
$$

$$
\Rightarrow \frac{120}{25}+\beta^{2}-\frac{12 \beta}{5}-4=0
$$

$$
\Rightarrow 25 \beta^{2}-60 \beta+20=0
$$

$$
\Rightarrow 5 \beta^{2}-12 \beta+4=0
$$

$$
\Rightarrow \quad \beta=2, \frac{2}{5}
$$

Take $\beta=2$
$\frac{\beta}{\alpha}=\frac{2}{1}=2$


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18. The number of solutions of the equation $4 \sin ^{2} x-4$ $\cos ^{3} x+9-4 \cos x=0 ; x \in[-2 \pi, 2 \pi]$ is :
(1) 2
(2) 0
(3) 3
(4) 1

## Answer (2)

Sol. $4-4 \cos ^{2} x-4 \cos ^{3} x-4 \cos x+9=0$
$4 \cos ^{3} x+4 \cos ^{2} x+4 \cos x-13=0$
$\left(\cos ^{2} x+\frac{1}{2}\right)^{2}+\frac{3}{4}=\frac{13}{4} \sec x$
L.H.S $\in[1,3]$
R.H.S $\in\left(-\infty, \frac{-13}{4}\right] \cup\left[\frac{13}{4}, \infty\right)$
$\therefore \quad$ Number of solutions $=0$
19. The value of $\int_{0}^{1}\left(2 x^{3}-3 x^{2}-x+1\right)^{\frac{1}{3}} d x$ is equal to :
(1) 1
(2) 0
(3) 2
(4) -1

Answer (2)
Sol. $I=\int_{0}^{1}\left(2 x^{3}-3 x^{2}-x+1\right)^{1 / 3} d x$
$I=\int_{0}^{1}\left((2 x-1)\left(x^{2}-x-1\right)\right)^{1 / 3} d x$
$I=\int_{0}^{1}\left[(2(1-x)-1)\left((1-x)^{2}-(1-x)-1\right)\right]^{1 / 3} d x$
$I=\int_{0}^{1}\left((1-2 x)\left(x^{2}-x-1\right)\right)^{1 / 3} d x$
$I=-\int_{0}^{1}\left((2 x-1)\left(x^{2}-x-1\right)\right)^{1 / 3} d x$
$I=-1$
$2 l=0$
$I=0$
20. Let $\alpha$ be non-zero real number. Suppose $f: R \rightarrow R$ is a differentiable function such that $f(0)=2$ and $\lim _{x \rightarrow-\infty} f(x)=1$. If $f^{\prime}(x)=\alpha f(x)+3$, for all $x \in R$, then $f\left(-\log _{e} 2\right)$ is equal to $\qquad$ _.
(1) 5
(2) 3
(3) 7
(4) 9

## Answer (4 OR Bonus)

Sol. $f^{\prime}(x)=\alpha f(x)+3$
$f^{\prime}(x)+(-\alpha) f(x)=3$
I.F. $=e^{\int-\alpha d x}=e^{-\alpha x}$
$\Rightarrow f(x) \cdot e^{-\alpha x}=\int 3 e^{-\alpha x} d x+c$
$\Rightarrow f(x) e^{-\alpha x}=-\frac{3}{\alpha} e^{-\alpha x}+c$
$f(x)=-\frac{3}{\alpha}+c e^{\alpha x}, \because f(0)=2 \Rightarrow c=2+\frac{3}{\alpha}$
$\Rightarrow f(x)=-\frac{3}{\alpha}+\left(2+\frac{3}{\alpha}\right) e^{\alpha x}$
$\lim _{x \rightarrow-\infty} f(x)=\lim _{x \rightarrow-\infty}\left(-\frac{3}{\alpha}+c e^{\alpha x}\right)=1$
$-\frac{3}{\alpha}+c \lim _{x \rightarrow-\infty} e^{\alpha x}=1$
$\Rightarrow \alpha=3$ (not possible as $\alpha>0$ )
If $\alpha<0$,
$\because f(x)=-\frac{3}{\alpha}+\left(2+\frac{3}{\alpha}\right) e^{\alpha x}$
$\lim _{x \rightarrow-\infty} e^{-\alpha x} f(x)=\lim _{x \rightarrow-\infty}\left(-\frac{3}{\alpha} e^{-\alpha x}+\left(2+\frac{3}{\alpha}\right)\right)$
$2+\frac{3}{\alpha}=0 \Rightarrow \alpha=-\frac{3}{2} \Rightarrow f(x)=2 \forall x \in R$
$\Rightarrow \lim _{x \rightarrow-\infty} f(x)=2$ (but it given that $\lim _{x \rightarrow-\infty} f(x)=1$ )
not possible
Note: If in the question, it was given $\lim _{x \rightarrow \infty} f(x)=1$ in place of $\lim _{x \rightarrow-\infty} f(x)=1$


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Then
$f(x)=-\frac{3}{\alpha}+\left(2+\frac{3}{\alpha}\right) e^{\alpha x}$
$\because \lim _{x \rightarrow \infty} f(x)=1$
$\Rightarrow \lim _{x \rightarrow \infty}\left(-\frac{3}{\alpha}+\left(2+\frac{3}{\alpha}\right) e^{\alpha x}\right)=1$
If $\alpha<0$, then $-\frac{3}{\alpha}=1 \Rightarrow \alpha=-3$
and $f(x)=1+e^{-3 x}$
$\Rightarrow f(-\ln 2)=9$

## 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 $A=I_{2}-2 \mathrm{MM}^{\top}$, where $M$ is a real matrix of order $2 \times 1$ such that the relation $M^{\top} M=\Lambda_{1}$ holds. If $\lambda$ is a real number such that the relation $A X=\lambda X$ holds for some non-zero real matrix $X$ of order $2 \times 1$, then the sum of squares of all possible values of $\lambda$ is equal to $\qquad$ .

Answer (2)
Sol. $A=I_{2}-2 M M^{\top}$

$$
\begin{aligned}
& A^{2}=\left(I_{2}-2 M M^{T}\right)\left(I_{2}-2 M M^{T}\right) \\
& =I_{2}-2 M M^{T}-2 M M^{T}+4 M M^{T} M M^{T} \\
& =I_{2}-4 M M^{T}+4 M M^{T} \\
& =I_{2} \\
& A X=\lambda X \\
& A^{2} X=\lambda A X \\
& X=\lambda(\lambda X) \\
& X=\lambda^{2} X
\end{aligned}
$$

$X\left(\lambda^{2}-1\right)=0$
$\lambda^{2}=1$
$\lambda^{2}= \pm 1$
Sum of square of all values $=2$.
22. Let $A B C$ be an isosceles triangle in which $A$ is at $(-1,0), \angle A=\frac{2 \pi}{3}, A B=A C$ and $B$ is on the positive $x$-axis. If $B C=4 \sqrt{3}$ and the line $B C$ intersects the line $y=x+3$ at $(\alpha, \beta)$, then $\frac{\beta^{4}}{\alpha^{2}}$ is $\qquad$ .

## Answer (36)



$$
\begin{aligned}
& \frac{c}{\sin 30}=\frac{4 \sqrt{3}}{\sin 120} \\
& \Rightarrow c=4
\end{aligned}
$$

$$
A B=|(b+1)|=4
$$

$$
b=3 m_{A B}=0
$$

$$
m_{B C}=\frac{-1}{\sqrt{3}}
$$

$$
B C: y=-\frac{1}{\sqrt{3}}(x-3)
$$

$$
: \sqrt{3} y+x=4
$$

Point of intersection of $y=x+3, \sqrt{3} y+x=3$
$y=\frac{6}{\sqrt{3}+1}$ and $x=\frac{-6}{(1+\sqrt{3})^{2}}$
$\frac{\beta^{4}}{\alpha^{2}}=36$


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23. If three successive terms of a G.P. with common ratio $r(r>1)$ are the lengths of the sides of a triangle and $[r]$ denotes the greatest integer less than or equal to $r$, then $3[r]+[-r]$ is equal to $\qquad$ .

## Answer (1)

Sol. Let three terms of G.P. are $\frac{a}{r}, a, \operatorname{ar}(r>1)$
Sum of two sides $>$ third side

$$
\begin{aligned}
\frac{a}{r}+a>a r & \Rightarrow 1+r>r^{2} \\
& \Rightarrow r^{2}-r-1<0 \\
& \Rightarrow \frac{1-\sqrt{5}}{2}<r<\frac{1+\sqrt{5}}{2}
\end{aligned}
$$

but $r>1$
$\Rightarrow \quad r \in\left(1, \frac{1+\sqrt{5}}{2}\right)$
$\Rightarrow[r]=1$ and $[-r]=-2$
$3[r]+[-r]=3-2=1$
24. The lines $L_{1}, L_{2}, \ldots, L_{20}$ are distinct. For $n=1,2,3$, ..., 10 all the lines $L_{2 n-1}$ are parallel to each other and all the lines $L_{2 n}$ pass through a given $P$. the maximum number of points of intersection of pairs of lines from the set $\left[L_{1}, L_{2}, \ldots, L_{20}\right]$ is equal to
$\qquad$ .

## Answer (101)

Sol. 10 lines are concurrent, 10 lines are parallel.
Odd lines $\in\left\{I_{1}, I_{3}, \ldots . . ., I_{19}\right\}$
Even lines $\in\left\{I_{2}, I_{4}, \ldots \ldots ., I_{20}\right\}$
For maximum intersection
Even lines $C_{2} \times$ (Zero point of intersection) + (One line from odd) $\times$ (One line from even lines) +1 point of intersection of concurrent lines
$={ }^{10} C_{2}(0)+{ }^{10} C_{1}{ }^{10} C_{1}+1$
= 101
25. The sum of squares of all possible values of $k$, for which area of the region bounded by the parabolas $2 y^{2}=k x$ and $k y^{2}=2(y-x)$ is maximum, is equal to
$\qquad$ -.

## Answer (08)

Sol. Given $k y^{2}=2(y-x)$
$2 y^{2}=k x$
Point of intersection of (i) and (ii)

$$
\begin{aligned}
& k y^{2}=2\left(y-\frac{2 y^{2}}{k}\right) \\
& \Rightarrow \quad y=0, k y=2\left(1-\frac{2 y}{k}\right) \\
& k y+\frac{4 y}{k}=2 \\
& y=\frac{2}{k+\frac{4}{k}}=\frac{2 k}{k^{2}+4} \\
& A=\int_{6}^{\frac{2 k}{k^{2}+4}}\left(\left(y-\frac{k y^{2}}{2}\right)-\frac{2 y^{2}}{k}\right) d y \\
& A=\left[\frac{y^{2}}{2}-\left(\frac{k}{2}+\frac{2}{k}\right) \frac{y^{3}}{3}\right]_{0}^{\frac{2 k}{k^{2}+4}} \\
& =\left(\frac{2 k}{k^{2}+4}\right)^{2}\left[\frac{1}{2}-\frac{k^{2}+4}{2 k}\left(\frac{1}{3}\right)\left(\frac{2 k}{k^{2}+4}\right)\right]
\end{aligned}
$$

$$
=\frac{1}{6} \times 4 \times\left(\frac{1}{k+\frac{4}{k}}\right)^{2}
$$

A.M. $\geq$ G.M.
$\frac{\left(k+\frac{4}{k}\right)}{2} \geq 2$
$k+\frac{4}{k} \geq 4$


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$\therefore$ Area is maximum when $k=\frac{4}{k}$
$\therefore \quad k^{2}=4$
$k= \pm 2$
$k_{1}=2, k_{2}=-2$
$\therefore \quad k_{1}^{2}+k_{2}^{2}=(+2)^{2}+(-2)^{2}$

$$
=4+4
$$

$$
=08
$$

26. If $y=\frac{(\sqrt{x}+1)\left(x^{2}-\sqrt{x}\right)}{x \sqrt{x}+x+\sqrt{x}}+\frac{1}{15}\left(3 \cos ^{2} x-5\right) \cos ^{3} x$, then $96 y^{\prime}\left(\frac{\pi}{6}\right)$ is equal to $\qquad$ .

## Answer (105)

Sol. $y=\frac{(\sqrt{x}+1)\left(x^{2}-\sqrt{x}\right)}{x \sqrt{x}+x+\sqrt{x}}+\frac{1}{15}\left(3 \cos ^{2} x-5\right) \cos ^{3} x$
$\Rightarrow \quad y=\frac{(\sqrt{x}+1) \sqrt{x}(\sqrt{x}-1)(x+\sqrt{x}+1)}{\sqrt{x}(x+\sqrt{x}+1)}$

$$
+\frac{1}{5} \cos ^{5} x-\frac{1}{3} \cos ^{3} x
$$

$\Rightarrow y=x-1+\frac{1}{5} \cos ^{5} x-\frac{1}{3} \cos ^{3} x$
$\Rightarrow \quad \frac{d y}{d x}=1+\cos ^{4} x(-\sin x)+\cos ^{2} x \cdot \sin x$
$\left.\Rightarrow \frac{d y}{d x}\right|_{x=\frac{\pi}{6}}=1+\left(\frac{\sqrt{3}}{2}\right)^{4}\left(-\frac{1}{2}\right)+\left(\frac{\sqrt{3}}{2}\right)^{2}\left(\frac{1}{2}\right)=\frac{35}{32}$
Required value $=96 \times \frac{35}{32}=105$
27. Let

$$
\vec{a}=\hat{i}+\hat{j}+\hat{k}, \vec{b}=-\hat{i}-8 \hat{j}+2 \hat{k}
$$

and $\vec{c}=4 \hat{i}+c_{2} \hat{j}+c_{3} \hat{k}$, be three vectors such that $\vec{b} \times \vec{a}=\vec{c} \times \vec{a}$. If the angle between the vector $\vec{c}$ and the vector $3 \hat{i}+4 \hat{j}+\hat{k}$ is $\theta$, then the greatest integer less than or equal to $\tan ^{2} \theta$ is $\qquad$ .

## Answer (38)

Sol. $\vec{b} \times \vec{a}=\vec{c} \times \vec{a}-$
$\Rightarrow \quad(\vec{c}-\vec{b}) \times \vec{a}=0$
$\Rightarrow \quad \vec{c}=\vec{b}+\lambda \vec{a}$
$\Rightarrow \quad \vec{c}=(-1+\lambda) \hat{i}+(-8+\lambda) \hat{j}+(2+\lambda) \hat{k}$
But given $\vec{c}=4 \hat{i}+c_{2} \hat{j}+c_{3} \hat{k}$
$\Rightarrow \lambda=5, c_{2}=-3$ and $c_{3}=7$
Hence $\vec{c}=4 \hat{i}-3 \hat{j}+7 \hat{k}$
Let $\vec{x}=-3 \hat{i}+4 \hat{j}+\hat{k}$
If angle between $\vec{c}$ and $\vec{x}$ is $\theta$ then
$\cos \theta=\frac{12-12+7}{\sqrt{16+9+49} \sqrt{9+16+1}}$
$\tan ^{2} \theta=\frac{1}{\cos ^{2} \theta}-1=\frac{74 \times 26}{49}-1 \approx 38.26$
Required value $=38$
28. If $\frac{d x}{d y}=\frac{1+x-y^{2}}{y}, x(1)=1$, then $5 x(2)$ is equal to

Answer (5)
Sol. $\frac{d x}{d y}=\frac{1+x-y^{2}}{y}$

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

Integrating factor (I.F.) $=e^{-\int \frac{1}{y} d y}=e^{\ln \left(\frac{1}{y}\right)}=\frac{1}{y}$

$$
\begin{array}{cc}
\Rightarrow \quad x \cdot \frac{1}{y}=\int\left(\frac{1-y^{2}}{y^{2}}\right) d y \\
\Rightarrow \quad x=-1-y^{2}+c y \\
& x(1)=1 \Rightarrow c=3 \\
\Rightarrow \quad x(y)=3 y-1-y^{2} \\
& 5 \cdot x(2)=5(6-1-4) \\
& =5
\end{array}
$$



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29. Let $f:(0, \infty) \rightarrow \mathbf{R}$ and $F(x)=\int_{0}^{x} t f(t) d t$. If $F\left(x^{2}\right)=x^{4}+$ $x^{5}$, then $\sum_{r=1}^{12} f\left(r^{2}\right)$ is equal to $\qquad$ .

## Answer (219)

Sol. $\because F(x)=\int_{0}^{x} t f(t) d t$
$\Rightarrow \quad F^{\prime}(x)=x \cdot f(x)$
Also $F\left(x^{2}\right)=x^{4}+x^{5}$
$\Rightarrow F(x)=x^{2}+x^{\frac{5}{2}}$
$F^{\prime}(x)=2 x+\frac{5}{2} \cdot x^{\frac{3}{2}}$
From (i) and (ii)
$f(x)=2+\frac{5}{2} \sqrt{x}$
$\sum_{r=1}^{12} f\left(r^{2}\right)=\sum_{r=1}^{12}\left(2+\frac{5}{2} r\right)$
$=2 \times 12+\frac{5}{2}\left(\frac{12 \times 13}{2}\right)$
$=219$
30. Three points $O(0,0), P\left(a, a^{2}\right), Q\left(-b, b^{2}\right), a>0$, $b>0$, are on the parabola $y=x^{2}$. Let $S_{1}$ be the area of the region bounded by the line $P Q$ and the parabola, and $S_{2}$ be the area of the triangle $O P Q$. If the minimum value of $\frac{S_{1}}{S_{2}}$ is $\frac{m}{n}, g c d(m, n)=1$, then $m+n$ is equal to $\qquad$
Answer (7)


Equation of $P Q$

$$
\begin{aligned}
& y+b=\frac{a^{2}-b^{2}}{a+b}\left(x-b^{2}\right) \\
& \Rightarrow \quad y=(a-b) x+a b \\
& S_{1}=\int_{-b}^{a}\left((a-b) x+a b-x^{2}\right) d x \\
& =\left(\frac{(a-b)}{2} x^{2}+a b x-\frac{x^{3}}{3}\right)_{-b}^{a} \\
& =\frac{1}{6}(a+b)^{3} \\
& S_{2}=\frac{1}{2}\left|\begin{array}{ccc}
-b & b^{2} & 1 \\
0 & 0 & 1 \\
a & a^{2} & 1
\end{array}\right|=\frac{1}{2} a b(a+b) \\
& \frac{S_{1}}{S_{2}}=\frac{\frac{1}{6}(a+b)^{3}}{\frac{1}{2} \cdot a b(a+b)} \\
& =\frac{1}{3} \frac{(a+b)^{2}}{a b}=\frac{1}{3}\left(\frac{a}{b}+\frac{b}{a}+2\right) \\
& \because \frac{b}{a}+\frac{a}{b} \geq 2 \\
& \Rightarrow\left(\frac{S_{1}}{S_{2}}\right)_{\text {min }}=\frac{4}{3}=\frac{m}{n} \\
& \Rightarrow m+n=7
\end{aligned}
$$

Sol.

## 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. A disc of radius $R$ and mass $M$ is rolling horizontally without slipping with speed $v$. It then moves up an inclined smooth surface as shown in figure. The maximum height that the disc can go up the incline is

(1) $\frac{2}{3} \frac{v^{2}}{g}$
(2) $\frac{v^{2}}{g}$
(3) $\frac{3}{4} \frac{v^{2}}{g}$
(4) $\frac{1}{2} \frac{v^{2}}{g}$

Answer (4)
Sol. $\frac{1}{2} M v^{2}=M g h$
(No change in $\mathrm{KE}_{\text {rotational }}$
$h=\frac{1}{2} \frac{v^{2}}{g}$
32. A light planet is revolving around a massive star in a circular orbit of radius $R$ with a period of revolution $T$. If the force of attraction between planet and star is proportional to $R^{-3 / 2}$ then choose the correct option
(1) $T^{2} \propto R^{5 / 2}$
(2) $T^{2} \propto R^{3}$
(3) $T^{2} \propto R^{3 / 2}$
(4) $T^{2} \propto R^{7 / 2}$

Answer (1)

Sol. $F=\frac{m v^{2}}{R} \Rightarrow \frac{K}{R^{3 / 2}}=\frac{m v^{2}}{R} \Rightarrow v=\frac{K^{\prime}}{R^{1 / 4}}$
$T=\frac{2 \pi R}{V}=\frac{2 \pi R}{\frac{K}{R^{1 / 4}}}=\frac{2 \pi}{K} R^{5 / 4}$
$T \propto R^{5 / 4} \Rightarrow T^{2} \propto R^{5 / 2}$
33. Monochromatic light of frequency $6 \times 10^{14} \mathrm{~Hz}$ is produced by a laser. The power emitted is $2 \times 10^{-3} \mathrm{~W}$. How many photons per second on an average, are emitted by the source?
(Given $h=6.63 \times 10^{-34} \mathrm{Js}$ )
(1) $6 \times 10^{15}$
(2) $5 \times 10^{15}$
(3) $7 \times 10^{16}$
(4) $9 \times 10^{18}$

Answer (2)
Sol. $n=\frac{\text { Power }}{\text { Energy of one photon }}=\frac{P}{h v}$
$n=\frac{2 \times 10^{-3}}{6.63 \times 10^{-34} \times 6 \times 10^{14}}=5 \times 10^{15}$
34. Conductivity of a photodiode starts changing only if the wavelength of incident light is less than 660 nm . The band gap of photodiode is found to be $\left(\frac{X}{8}\right) \mathrm{eV}$. The value of $X$ is
(Given, $h=6.6 \times 10^{-34} \mathrm{Js}, e=1.6 \times 10^{-19} \mathrm{C}$ )
(1) 13
(2) 11
(3) 21
(4) 15

Answer (4)
Sol. $E=\frac{h c}{\lambda} \Rightarrow\left(\frac{X}{8}\right) \mathrm{eV}=\left(\frac{1240}{660}\right) \mathrm{eV}$
$X=\frac{124 \times 8}{66} \simeq 15$

35. A diatomic gas $(\gamma=1.4)$ does 200 J of work when it is expanded isobarically. The heat given to the gas in the process is
(1) 800 J
(2) 600 J
(3) 700 J
(4) 850 J

Answer (3)
Sol. $W=n R \Delta T \Rightarrow \Delta T=\frac{200}{n R}$
and $Q=U+W=\frac{F}{2} n R \Delta T+n R \Delta T=\left(\frac{F}{2}+1\right) n R \Delta T$
$\Rightarrow Q=\left(\frac{5}{2}+1\right) \times n R \times \frac{200}{n R}=700 \mathrm{~J}$
36. A big drop is formed by coalescing 1000 small droplets of water. The surface energy will become
(1) 100 times
(2) $\frac{1}{100} \mathrm{th}$
(3) $\frac{1}{10}$ th
(4) 10 times

## Answer (3)

Sol. $\therefore \frac{4}{3} \pi r^{3} \times 1000=\frac{4}{3} \pi R^{3} \Rightarrow R=10 r$
Initial surface energy $=k . \pi r^{2} \times 1000$
Final surface energy $=k \cdot \pi(10 r)^{2}$
$E_{f}=\frac{1}{10} E_{i}$
37. A cricket player catches a ball of mass 120 g moving with $25 \mathrm{~m} / \mathrm{s}$ speed. If the catching process is completed in 0.1 s , then the magnitude of force exerted by the ball on the hand of player will be (in SI unit)
(1) 24
(2) 25
(3) 30
(4) 12

Answer (3)

Sol. Force exerted $=\frac{\Delta P}{\Delta t}=\frac{0.12 \times 25-0}{0.10}$

$$
\begin{aligned}
& =\frac{12 \times 25}{10} \mathrm{~N} \\
& =30 \mathrm{~N}
\end{aligned}
$$

38. In an ammeter, $5 \%$ of the main current passes through the galvanometer. If resistance of the galvanometer is G , the resistance of ammeter will be
(1) 200 G
(2) $\frac{G}{199}$
(3) 199 G
(4) $\frac{G}{200}$

## Answer (None of these)

Sol.

39. A microwave of wavelength 2.0 cm falls normally on a slit of width 4.0 cm . The angular spread of the central maxima of the diffraction pattern obtained on a screen 1.5 m away from the slit, will be
(1) $45^{\circ}$
(2) $15^{\circ}$
(3) $60^{\circ}$
(4) $30^{\circ}$

Answer (3)


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Sol. Half angular spread : $\theta$; $d \sin \theta=\lambda$
$\sin \theta=\frac{\lambda}{d}=\frac{2}{4}=\frac{1}{2} \Rightarrow \theta=30^{\circ}$
Angular spread $=2 \theta=60^{\circ}$
40. From the statements given below :
(A) The angular momentum of an electron in $n^{\text {th }}$ orbit is an integral multiple of $\hbar$.
(B) Nuclear forces do not obey inverse square law.
(C) Nuclear forces are spin dependent.
(D) Nuclear forces are central and charge independent.
(E) Stability of nucleus is inversely proportional to the value of packing fraction.

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

Answer (4)
Sol. (D) is incorrect. Rest all are correct.
Nuclear forces are non-central forces.
41. A galvanometer $(G)$ of $2 \Omega$ resistance is connected in the given circuit. The ratio of charge stored in $C_{1}$ and $C_{2}$ is

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

## Answer (4)

Sol. $i_{\text {steady }}=\frac{6}{12}=\frac{1}{2} A$
$q_{1}=C_{1} \times \Delta V_{1}=6 \times 4 \times 3=12 \mu C$
$q_{2}=C_{2} \times \Delta V_{2}=6 \times 4=24 \mu C$
$\frac{q_{1}}{q_{2}}=\frac{1}{2}$
42. To measure the temperature coefficient of resistivity $\alpha$ of a semiconductor, an electrical arrangement shown in the figure is prepared. The arm $B C$ is made up of the semiconductor. The experiment is being conducted at $25^{\circ} \mathrm{C}$ and resistance of the semiconductor arm is $3 \mathrm{~m} \Omega$. Arm $B C$ is cooled at a constant rate of $2^{\circ} \mathrm{C} / \mathrm{s}$. If the galvanometer $G$ shows no deflection after 10 s , then $\alpha$ is

(1) $-1 \times 10^{-2}{ }^{\circ} \mathrm{C}^{-1}$
(2) $-2.5 \times 10^{-2}{ }^{\circ} \mathrm{C}^{-1}$
(3) $-1.5 \times 10^{-2}{ }^{\circ} \mathrm{C}^{-1}$
(4) $-2 \times 10^{-2}{ }^{\circ} \mathrm{C}^{-1}$

## Answer (1)

Sol. $\therefore$ Wheatstone bridge : $0.8 \times 3=1 \times R$
$R=2.4 \mathrm{mr} \Omega$
$R=R_{0}(1+\alpha \Delta T) \Rightarrow 2.4=3(1+20 \alpha)$
$\frac{2.4}{3}-1=20 \alpha \Rightarrow-\frac{0.6}{3 \times 20}=\alpha=-1 \times 10^{-2}{ }^{\circ} \mathrm{C}^{-1}$


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43. Train $A$ is moving along two parallel rail tracks towards north with speed $72 \mathrm{~km} / \mathrm{h}$ and train $B$ is moving towards south with speed $108 \mathrm{~km} / \mathrm{h}$. Velocity of train $B$ with respect to $A$ and velocity of ground with respect to $B$ are (in $\mathrm{ms}^{-1}$ )
(1) -50 and -30
(2) 50 and -30
(3) -50 and 30
(4) -30 and 50

## Answer (3)

Sol. $\vec{V}_{B A}=\vec{V}_{B}-\vec{V}_{A}=-30-20=-50 \mathrm{~m} / \mathrm{s}$
$\vec{V}_{G B}=\vec{V}_{G}-\vec{V}_{B}=0-(-30)=30 \mathrm{~m} / \mathrm{s}$
44. If frequency of electromagnetic wave is 60 MHz and it travels in air along $z$ direction then the corresponding electric and magnetic field vectors will be mutually perpendicular to each other and the wavelength of the wave (in m ) is
(1) 2
(2) 2.5
(3) 10
(4) 5

## Answer (4)

Sol. $\lambda=\frac{c}{f}=\frac{3 \times 10^{8}}{60 \times 10^{6}}=\frac{30 \times 10^{7}}{6 \times 10^{7}}$
$=5 \mathrm{~m}$
45. A body of mass 4 kg experiences two forces $\vec{F}_{1}=5 \hat{i}+8 \hat{j}+7 \hat{k}$ and $\vec{F}_{2}=3 \hat{i}-4 \hat{j}-3 \hat{k}$.

The acceleration acting on the body is
(1) $-2 \hat{i}-\hat{j}-\hat{k}$
(2) $2 \hat{i}+\hat{j}+\hat{k}$
(3) $4 \hat{i}+2 \hat{j}+2 \hat{k}$
(4) $2 \hat{i}+3 \hat{j}+3 \hat{k}$

## Answer (2)

Sol. $\vec{a}=\frac{\vec{F}_{\text {net }}}{m}=\frac{(5 \hat{i}+8 \hat{j}+7 \hat{k})+(3 \hat{i}-4 \hat{j}-3 \hat{k})}{4}$

$$
=2 \hat{i}+\hat{j}+\hat{k}
$$

46. Match List-I with List-II.

|  | List-I <br> (Number) |  | List-II <br> (Significant figure) |
| :--- | :--- | :--- | :--- |
| (A) | 1001 | (I) | 3 |
| (B) | 010.1 | (II) | 4 |
| (C) | 100.100 | (III) | 5 |
| (D) | 0.0010010 | (IV) | 6 |

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

## Answer (1)

Sol. Significant figures are as
$\therefore 1001: 4 ; 010.1: 3 ; 100.100: 6$;
0.0010010 : 5
(Significant figures)
47. If the root mean square velocity of hydrogen molecule at a given temperature and pressure is 2 $\mathrm{km} / \mathrm{s}$, the root mean square velocity of oxygen at the same condition in $\mathrm{km} / \mathrm{s}$ is :
(1) 1.5
(2) 1.0
(3) 0.5
(4) 2.0

## Answer (3)

Sol. $V_{\mathrm{RMS}} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{V_{\mathrm{O}_{2}}}{V_{\mathrm{H}_{2}}}=\sqrt{\frac{M_{\mathrm{H}_{2}}}{M_{\mathrm{O}_{2}}}} \Rightarrow \frac{V_{\mathrm{O}_{2}}}{2}=\sqrt{\frac{2}{32}}$
$\Rightarrow \quad V_{\mathrm{O}_{2}}=\frac{2}{4}=0.5 \mathrm{~km} / \mathrm{s}$

48. In a metre-bridge when a resistance in the left gap is $2 \Omega$ and unknown resistance in the right gap, the balance length is found to be 40 cm . On shunting the unknown resistance with $2 \Omega$, the balance length changes by
(1) 22.5 cm
(2) 20 cm
(3) 65 cm
(4) 62.5 cm

## Answer (1)

Sol. $\therefore \quad$ Value of $R: \frac{2}{R}=\frac{40}{60} \Rightarrow R=3 \Omega$

After shunting : $\frac{2}{6 / 5}=\frac{I}{100-I} \Rightarrow I=62.5 \mathrm{~cm}$
Shifting of length $=62.5-40=22.5 \mathrm{~cm}$
49. A transformer has an efficiency of $80 \%$ and works at 10 V and 4 kW . If the secondary voltage is 240

V , then the current in the secondary coil is
(1) 1.59 A
(2) 15.1 A
(3) 13.33 A
(4) 1.33 A

## Answer (3)

Sol. $\eta=\frac{P_{\text {output }}}{P_{\text {input }}}=\frac{E_{s} \cdot l_{s}}{P_{\text {input }}} \Rightarrow \frac{80}{100}=\frac{240 \times i_{s}}{4000}$

$$
i_{s}=\frac{40}{3} \mathrm{~A}=13.33 \mathrm{~A}
$$

50. $C_{1}$ and $C_{2}$ are two hollow concentric cubes enclosing charges $2 Q$ and $3 Q$ respectively as shown in figure. The ratio of electric flux passing through $C_{1}$ and $C_{2}$ is:

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

## Answer (3)

Sol. $\phi_{C_{1}}=\frac{2 Q}{\varepsilon_{0}}, \phi_{C_{2}}=\frac{2 Q+3 Q}{\varepsilon_{0}}$

$$
\frac{\phi_{C_{1}}}{\phi_{C_{2}}}=\frac{2}{5} ; \phi_{C_{1}}: \phi_{C_{2}}=2: 5
$$

## 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. A uniform rod $A B$ of mass 2 kg and length 30 cm at rest on a smooth horizontal surface. An impulse of force 0.2 Ns is applied to end $B$. The time taken by the rod to turn through at right angles will be $\frac{\pi}{x} s$, where $x=$ $\qquad$ .

Answer (4)


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Sol. Angular impulse $=I \cdot \frac{I}{2}=\frac{m l^{2}}{12} \cdot w$
$\Rightarrow w=\frac{6 l}{m l}$
$w=2 \mathrm{rad} / \mathrm{s} ; \quad \because \theta=w t$
$\Rightarrow \quad \frac{\pi}{2}=2 \cdot t$
$\Rightarrow \quad t=\frac{\pi}{4}$
$\Rightarrow x=4$
52. Suppose a uniformly charged wall provides a uniform electric field of $2 \times 10^{4} \mathrm{~N} / \mathrm{C}$ normally. A charged particle of mass 2 g being suspended through a silk thread of length 20 cm and remain stayed at a distance of 10 cm from the wall. Then the charge on the particle will be $\frac{1}{\sqrt{x}} \mu \mathrm{C}$ where $x=$
$\qquad$ [Use $g=10 \mathrm{~m} / \mathrm{s}^{2}$ ]
Answer (3)
Sol. $\sin \theta=\frac{1}{2}$
$\Rightarrow \tan \theta=\frac{1}{\sqrt{3}}$
$\tan \theta=\frac{q E}{m g}=\frac{1}{\sqrt{3}}=\frac{1 \times 2 \times 10^{4} \times 10^{-6}}{\sqrt{x} \times 20 \times 10^{-3}}$
$\Rightarrow x=3$
53. One end of a metal wire is fixed to a ceiling and a load of 2 kg hangs from the other end. A similar wire is attached to the bottom of the load and another load of 1 kg hangs from this lower wire. Then the ratio of longitudinal stain of upper wire to that of the lower wire will be $\qquad$ .
[Area of cross section of wire $=0.005 \mathrm{~cm}^{2}$, $Y=2 \times 10^{11} \mathrm{Nm}^{-2}$ and $\left.g=10 \mathrm{~ms}^{-2}\right]$

Answer (3)

Sol. Strain $=\frac{\text { Stress }}{Y}=\frac{F}{A Y}$
$\Rightarrow$ Stress $\propto F$
$\frac{(\text { Stress })_{U}}{(\text { Stress })_{L}}=\frac{F_{U}}{F_{L}}=\frac{30}{10}=3$
54. A particle initially at rest starts moving from reference point $x=0$ along $x$-axis, with velocity $v$ that varies as $v=4 \sqrt{x} \mathrm{~m} / \mathrm{s}$. The acceleration of the particle is $\qquad$ $\mathrm{ms}^{-2}$.

## Answer (8)

Sol. $a=v \cdot \frac{d v}{d x}$
$\Rightarrow \quad a=4 \sqrt{x} \cdot \frac{4}{2 \sqrt{x}}$
$\Rightarrow \quad a=8 \mathrm{~m} / \mathrm{s}^{2}$
55. A mass $m$ is suspended from a spring of negligible mass and the system oscillates with a frequency $f_{1}$. The frequency of oscillations if a mass $9 m$ is suspended from the same spring is $f_{2}$. The value of $\frac{f_{1}}{f_{2}}$ is $\qquad$ .

## Answer (3)

Sol. $F=\frac{1}{2 \pi} \sqrt{\frac{K}{m}}$
$\Rightarrow F \propto \frac{1}{\sqrt{m}}$
$\frac{F_{1}}{F_{2}}=\sqrt{\frac{m_{2}}{m_{1}}}=\sqrt{\frac{9 m}{m}}=3$


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56. In Young's double slit experiment, monochromatic light of wavelength $5000 \AA$ is used. The slits are 1.0 mm apart and screen is placed at 1.0 m away from slits. The distance from the centre of the screen where intensity becomes half of the maximum intensity for the first time is $\qquad$ $\times 10^{-6} \mathrm{~m}$.

## Answer (125)

Sol. $2 I_{0}=4 I_{0} \cos ^{2}\left(\frac{\Delta \phi}{2}\right) \Rightarrow \cos \frac{\Delta \phi}{2}=\frac{1}{\sqrt{2}} \Rightarrow \phi=\frac{\pi}{2}$
$y=\frac{\Delta x \cdot D}{d}=\frac{\lambda \phi \cdot D}{2 \pi d}=\frac{\lambda D}{4 d}=\frac{5 \times 10^{-7} \times 1}{4 \times 10^{-3}}$
$y=125 \times 10^{-6}$
57. A particular hydrogen-like ion emits the radiation of frequency $3 \times 10^{15} \mathrm{~Hz}$ when it makes transition from $n=2$ to $n=1$. The frequency of radiation emitted in transition from $n=3$ to $n=1$ is $\frac{x}{9} \times 10^{15} \mathrm{~Hz}$, when $x=$ $\qquad$ -.
Answer (32)
Sol. $\frac{1}{\lambda_{1}}=\frac{F_{1}}{C}=R Z^{2}\left(\frac{1}{1}-\frac{1}{4}\right)=\frac{3}{4} R Z^{2} \Rightarrow F_{1}=3 \times 10^{15} \mathrm{~Hz}$

$$
\frac{3}{4} R Z^{2} \cdot C=3 \times 10^{15}
$$

$$
\frac{1}{\lambda_{2}}=\frac{F_{2}}{C}=R Z^{2}\left(\frac{1}{1}-\frac{1}{9}\right)=\frac{8}{9} R Z^{2} \Rightarrow F_{2}=\frac{8}{9} R Z^{2} \cdot C
$$

$$
F_{2}=\frac{8}{9} \times \frac{4}{3} \times 3 \times 10^{15}=\frac{32}{9} \times 10^{15} \mathrm{~Hz}
$$

58. In an electrical circuit drawn below the amount of charge stored in the capacitor is $\qquad$ $\mu \mathrm{C}$.


## Answer (60)

Sol. $i_{\text {steady }}=\frac{10}{10}=1 \mathrm{~A}$
$q=C \cdot V_{\text {steady }}=(10 \times 6) \mu \mathrm{C}=60 \mu \mathrm{C}$
59. A moving coil galvanometer has 100 turns and each turn has an area of $2.0 \mathrm{~cm}^{2}$. The magnetic field produced by the magnet is 0.01 T and deflection in the coil is 0.05 radian when a current of 10 mA is passed through it. The torsional constant of the suspension wire is $x \times 10^{-5} \mathrm{~N}-\mathrm{m} / \mathrm{rad}$. The value of $x$ is $\qquad$ .

## Answer (4)

Sol. $i=\frac{C \theta}{N B A} \Rightarrow C=\frac{N B A i}{\theta}=\frac{100 \times 0.01 \times 2 \times 10^{-4} \times 10^{-2}}{0.05}$
$C=\frac{2 \times 10^{-6}}{50 \times 10^{-3}}=4 \times 10^{-5} \mathrm{~N}-\mathrm{m} / \mathrm{rad}$
$\Rightarrow \quad x=4$
60. A coil of 200 turns and area $0.20 \mathrm{~m}^{2}$ is rotated at half a revolution per second and is placed in uniform magnetic field of 0.01 T perpendicular to axis of rotation of the coil. The maximum voltage generated in the coil is $\frac{2 \pi}{\beta}$ volt. The value of $\beta$ is

## Answer (5)

Sol. $T=2 \mathrm{sec} \Rightarrow \omega=\pi \mathrm{rad} / \mathrm{s}$
$\phi=N B A \cos \omega t \Rightarrow \varepsilon=N B A \omega \sin \omega t$
$\varepsilon_{0}=N B A \omega=200 \times 0.01 \times 0.2 \times \pi=0.4 \pi=\frac{2 \pi}{\beta}$
$\beta=5$

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## CHEMISTRY

## SECTION - A

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

## Choose the correct answer :

61. Lassaigne's test is used for detection of
(1) Nitrogen, Sulphur and Phosphorous only
(2) Nitrogen, Sulphur, Phosphorous and halogens
(3) Phosphorous and halogens only
(4) Nitrogen and Sulphur only

## Answer (2)

Sol. Nitrogen, sulphur, halogens and phosphorus present in an organic compound are detected by Lassaigne's test.
62. Given below are two statements:

Statement (I): $\mathrm{SiO}_{2}$ and $\mathrm{GeO}_{2}$ are acidic while SnO and PbO are amphoteric in nature.

Statement (II): Allotropic forms of carbon are due to property of catenation and $\mathrm{p} \pi-\mathrm{d} \pi$ bond formation. 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 false
(2) Both statement I and statement II are true
(3) Statement I is false but statement II is true
(4) Statement I is true but statement II is false

## Answer (4)

Sol. $\mathrm{SnO}, \mathrm{PbO}, \mathrm{SnO}_{2}, \mathrm{PbO}_{2}$ : Amphoteric
$\mathrm{CO}_{2}, \mathrm{SiO}_{2}, \mathrm{GeO}_{2}, \mathrm{GeO}$ : Acidic
CO : Neutral
$\mathrm{p} \pi-\mathrm{d} \pi$ bonding is not possible between two carbon atoms hence Statement I is true but Statement II is false.
63. The set of meta directing functional groups from the following sets is:
(1) $-\mathrm{NO}_{2},-\mathrm{NH}_{2},-\mathrm{COOH},-\mathrm{COOR}$
(2) $-\mathrm{NO}_{2},-\mathrm{CHO},-\mathrm{SO}_{3} \mathrm{H},-\mathrm{COR}$
(3) $-\mathrm{CN},-\mathrm{NH}_{2},-\mathrm{NHR},-\mathrm{OCH}_{3}$
(4) $-\mathrm{CN},-\mathrm{CHO},-\mathrm{NHCOCH}_{3},-\mathrm{COOR}$

## Answer (2)

Sol. $-\mathrm{NO}_{2},-\mathrm{CHO},-\mathrm{SO}_{3} \mathrm{H},-\mathrm{COR},-\mathrm{CN},-\mathrm{COOR}$ are having $-R$ effect hence meta directing for incoming electrophilic $-\mathrm{NH}_{2},-\mathrm{NHCOCH}_{3}$ are having +R effect.
64. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In aqueous solutions $\mathrm{Cr}^{2+}$ is reducing while $\mathrm{Mn}^{3+}$ is oxidising in nature.

Reason (R): Extra stability to half filled electronic configuration is observed than incompletely filled electronic configuration.

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In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both (A) and (R) are true and (R) is the correct explanation of (A)
(2) (A) is true but (R) is false
(3) Both (A) and (R) are true but (R) is not the correct explanation of $(A)$
(4) (A) is false but (R) is true

## Answer (1)

Sol. $\mathrm{Cr}^{2+}$ and $\mathrm{Mn}^{3+}$ both has $3 \mathrm{~d}^{4} 4 \mathrm{~s}^{0}$ configuration.
$\mathrm{Cr}^{3+}$ is reducing as its configuration changes from $d^{4}$ to $d^{3}$ having a half filled $t_{2 g}$ level and change from $\mathrm{Mn}^{3+}$ to $\mathrm{Mn}^{2+}$ results in the half filled $\mathrm{d}^{5}$ configuration which has extra stability.

Hence $\mathbf{A}$ and $\mathbf{R}$ both are true and $\mathbf{R}$ is correct explanation of $\mathbf{A}$.
65. The strongest reducing agent among the following is:
(1) $\mathrm{NH}_{3}$
(2) $\mathrm{BiH}_{3}$
(3) $\mathrm{PH}_{3}$
(4) $\mathrm{SbH}_{3}$

Answer (2)
Sol. Reducing character of the hydrides increases on moving down in the $15^{\text {th }}$ group hence Ammonia is only a mild reducing agent while $\mathrm{BiH}_{3}$ is strongest reducing agent.
66. $\mathrm{C}_{2} \mathrm{H}_{5} \mathrm{Br} \xrightarrow{\text { alc. } \mathrm{KOH}} \mathrm{A} \xrightarrow[\mathrm{CCl}_{4}]{\mathrm{Br}_{2}} \mathrm{~B} \xrightarrow[\text { Excess }]{\mathrm{KCN}} C \xrightarrow[\text { Excess }]{\mathrm{H}_{3} \mathrm{O}^{+}} \mathrm{D}$

Acid $D$ formed in above reaction is:
(1) Malonic acid
(2) Oxalic acid
(3) Gluconic acid
(4) Succinic acid

Answer (4)

Sol.


## Succinic acid

67. Given below are two statements:

Statement (I): A $\pi$ bonding MO has lower electron density above and below the inter-nuclear axis.

Statement (II): The $\pi^{*}$ antibonding MO has a node between the nuclei.

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

Answer (4)
Sol. $\because++\rightarrow+\stackrel{+}{\square}$ is $\pi_{2 p}$ (bonding M.O.)


Hence statement I is false and statement II is true
68. In the given reactions identify $A$ and $B$

(1) A : n-Pentane
B : trans-2-butene
(2) A: n-Pentane
B : Cis-2-butene
(3) A: 2-Pentyne
B : trans-2-butene
(4) A : 2-Pentyne
B : Cis-2-butene


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## Answer (3)

Sol.

(B)
69. Given below are two statements:

Statement (I): Both metals and non-metals exist in p and d-block elements

Statement (II): Non-metals have higher ionisation enthalpy and higher electronegativity than the metals.

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

## Answer (1)

Sol. $d$ block does not contain any non-metal.
Non-metallic character, ionisation enthalpy, electronegativity increases on moving left to right in a period and decreases on moving down the group.
70. Given below are two statements:

Statement I: Dimethyl glyoxime forms a sixmembered covalent chelate when treated with $\mathrm{NiCl}_{2}$ solution in presence of $\mathrm{NH}_{4} \mathrm{OH}$.

Statement II: Prussian blue precipitate contains iron both in (+2) and (+3) oxidation states.

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

## Answer (1)

Sol. Dimethyl glyoxime forms a six-membered chelate via hydrogen bonding/noncovalent force when treated with $\mathrm{NiCl}_{2}$ solution in presence of $\mathrm{NH}_{4} \mathrm{OH}$.

Prussian blue precipitate is
$\mathrm{Fe}_{4}\left[\mathrm{Fe}(\mathrm{CN})_{6}\right]_{3}$ has Fe at +3
as well as +2 oxidation state. Where ionisation sphere is $\mathrm{Fe}^{3+}$ and coordination sphere has $\mathrm{Fe}^{2+}$.
71. Which of the following compounds show colour due to d-d transition?
(1) $\mathrm{CuSO}_{4} .5 \mathrm{H}_{2} \mathrm{O}$
(2) $\mathrm{K}_{2} \mathrm{CrO}_{4}$
(3) $\mathrm{KMnO}_{4}$
(4) $\mathrm{K}_{2} \mathrm{Cr}_{2} \mathrm{O}_{7}$

Answer (1)
Sol. $\mathrm{Cu}^{2+}: 3 d^{9} 4 s^{\circ}$
$\mathrm{CuSO}_{4} .5 \mathrm{H}_{2} \mathrm{O}$ shows blue colour due to $\mathrm{d}-\mathrm{d}$ transition.

Compounds given in option (2), (3) and (4) show colour due to LMCT (ligend to metal charge transfer).
72. $\left[\mathrm{Co}\left(\mathrm{NH}_{3}\right)_{6}\right]^{3+}$ and $\left[\mathrm{CoF}_{6}\right]^{3-}$ are respectively known as:
(1) Spin free Complex, Spin paired Complex
(2) Inner orbital Complex, Spin paired Complex
(3) Spin paired Complex, Spin free Complex
(4) Outer orbital Complex, inner orbital Complex


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## Answer (3)

Sol. $\mathrm{Co}^{3+}: 3 d^{6} 4 s^{\circ}$
With $\mathrm{NH}_{3}$, pairing will take place
$\Rightarrow$ Spin paired complex
With $\mathrm{F}^{-}$, no paring will take place
$\Rightarrow$ Spin free complex.
73. Match List-I with List-II.

|  | List-I <br> Reactants |  | List-II <br> Product |
| :--- | :--- | :--- | :--- |
| (A) | Phenol, $\mathrm{Zn} / \Delta$ | (I) | Salicylaldehyde |
| (B) | Phenol, $\mathrm{CHCl}_{3}$, <br> $\mathrm{NaOH}, \mathrm{HCl}$ | (II) | Salicylic acid |
| (C) | Phenol, $\mathrm{CO}_{2}$, <br> $\mathrm{NaOH}, \mathrm{HCl}$ | (III) | Benzene |
| (D) | Phenol, <br> Conc, $\mathrm{HNO}_{3}$ | (IV) | Picric acid |

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

## Answer (2)

Sol. (A)

(B)


(C)


(D)

(Picric acid)
74. Which among the following has highest boiling point?
(1) $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{CH}_{2} \mathrm{CHO}$
(2) $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{CH}_{2} \mathrm{CH}_{2}-\mathrm{OH}$
(3) $\mathrm{H}_{5} \mathrm{C}_{2}-\mathrm{O}-\mathrm{C}_{2} \mathrm{H}_{5}$
(4) $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{CH}_{2} \mathrm{CH}_{3}$

## Answer (2)

Sol. $\mathrm{CH}_{3}-\mathrm{CH}_{2}-\mathrm{CH}_{2}-\mathrm{CH}_{2}-\mathrm{OH}$ will have highest boiling point due to intermolecular H -bonding.
75. The transition metal having highest $3^{\text {rd }}$ ionisation enthalpy is:
(1) Fe
(2) Mn
(3) Cr
(4) V

## Answer (2)

Sol. Mn: $3 d^{5} 4 s^{2}$
$\mathrm{Mn}^{2+}: 3 d^{5} 4 \mathrm{~s}^{\circ}$
Electron removal will be most difficult from $\mathrm{Mn}^{2+}$ due to half-filled configuration of $\mathrm{Mn}^{2+}$ ions.

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76. The functional group that shows negative resonance effect is :
(1) -COOH
(2) $-\mathrm{NH}_{2}$
(3) -OR
(4) -OH

Answer (1)

Sol.

77. Select the compound from the following that will show intramolecular hydrogen bonding.
(1) $\mathrm{NH}_{3}$
(2) $\mathrm{H}_{2} \mathrm{O}$
(3) $\mathrm{C}_{2} \mathrm{H}_{5} \mathrm{OH}$
(4)


## Answer (4)

Sol.

78. Match List-I with List-II.

|  | List-I <br> Compound |  | List-II <br> Use |
| :--- | :--- | :--- | :--- |
| (A) | Carbon <br> tetrachloride | (I) | Paint remover |
| (B) | Methylene <br> chloride | (II) | Refrigerators and air <br> conditioners |
| (C) | DDT | (III) | Fire extinguisher |
| (D) | Freons | (IV) | Non Biodegradable <br> insecticide |

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

## Answer (4)

Sol. A: Carbon tetrachloride is used in fire extinguisher.
$B$ : Methylene chloride is used in paint remover.
C: DDT is example of Non-biodegradable insecticide.

D : Freons are used in refrigerators and air conditioners.
79. Solubility of calcium phosphate (molecular mass, M ) in water is $\mathrm{W}_{\mathrm{g}}$ per 100 mL at $25^{\circ} \mathrm{C}$. Its solubility product at $25^{\circ} \mathrm{C}$ will approximately.
(1) $10^{7}\left(\frac{\mathrm{~W}}{\mathrm{M}}\right)^{3}$
(2) $10^{3}\left(\frac{W}{M}\right)^{5}$
(3) $10^{7}\left(\frac{W}{M}\right)^{5}$
(4) $10^{5}\left(\frac{W}{M}\right)^{5}$

Answer (3)
Sol. Solubility $=\left(\frac{10 \mathrm{~W}}{\mathrm{M}}\right) \frac{\mathrm{mol}}{\text { lit }}$
$K_{\text {sp }}=108(s)^{5}$
$k_{\text {sp }}=108(10)^{5} \times\left(\frac{W}{M}\right)^{5}$
$\approx 10^{7}\left(\frac{W}{M}\right)^{5}$


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80. The number of radial node/s for $3 p$ orbital is
(1) 4
(2) 3
(3) 1
(4) 2

Answer (3)
Sol. No. of radial nodes $=\mathrm{n}-\mathrm{I}-1$

$$
\begin{aligned}
& =3-1-1 \\
& =1
\end{aligned}
$$

## 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.
81. Consider the following redox reaction :

$$
\mathrm{MnO}_{4}^{-}+\mathrm{H}^{+}+\mathrm{H}_{2} \mathrm{C}_{2} \mathrm{O}_{4} \rightleftharpoons \mathrm{Mn}^{2+}+\mathrm{H}_{2} \mathrm{O}+\mathrm{CO}_{2}
$$

The standard reduction potentials are given below ( $\mathrm{E}_{\mathrm{red}}^{\circ}$ ) :

$$
\begin{aligned}
& \mathrm{E}_{\mathrm{MnO}_{4}^{-} / \mathrm{Mn}^{2+}}^{\circ}=+1.51 \mathrm{~V} \\
& \mathrm{E}_{\mathrm{CO}_{2} / \mathrm{H}_{2} \mathrm{C}_{2} \mathrm{O}_{4}}^{\circ}=-0.49 \mathrm{~V}
\end{aligned}
$$

If the equilibrium constant of the above reaction is given as $K_{\text {eq }}=10 \times$, then the value of $x=$ $\qquad$ (nearest integer)

## Answer (338)

Sol. $E_{\text {cell }}^{\circ}=(1.51)+0.49$

$$
\begin{aligned}
& =2.0 \mathrm{~V} \\
& 0=2-\frac{.0591}{10} \log \mathrm{~K} \\
& \operatorname{logK}=338.409 \\
& \mathrm{~K}=10^{338.409} \\
& \text { Nearest integer }=338
\end{aligned}
$$

82. Following Kjeldahl's method, 1 g of organic compound released ammonia, that neutralised 10 mL of $2 \mathrm{M} \mathrm{H}_{2} \mathrm{SO}_{4}$. The percentage of nitrogen in the compound is $\qquad$ \%.

## Answer (56)

Sol. Moles of $\mathrm{H}_{2} \mathrm{SO}_{4}=\frac{10 \times 2}{1000}=0.02$
Moles of $\mathrm{NH}_{3} \quad=0.04$
Moles of $\mathrm{N}=0.04$
Mass of $\mathrm{N} \quad=0.56 \mathrm{gm}$
\% by mass of $\mathrm{N}=56 \%$
83. 10 mL of gaseous hydrocarbon of combustion gives 40 mL of $\mathrm{CO}_{2}(\mathrm{~g})$ and 50 mL of water vapour. Total number of carbon and hydrogen atoms in the hydrocarbon is $\qquad$ _.

## Answer (14)

Sol. Number of carbon atoms $=\frac{40}{10}=4$
Number of H -atoms $=\frac{50 \times 2}{10}=10$
Total atoms $=(4+10)=14$
84. For a certain reaction at $300 \mathrm{~K}, \mathrm{~K}=10$, then $\Delta \mathrm{G}^{\circ}$ for the same reaction is - $\qquad$ $\times 10^{-1} \mathrm{~kJ} \mathrm{~mol}^{-1}$. (Given $\mathrm{R}=8.314 \mathrm{JK}^{-1} \mathrm{~mol}^{-1}$ )

## Answer (57)

Sol. $\Delta \mathrm{G}^{\circ}=-(2.303)(8.314)(300)$ logK

$$
\begin{aligned}
& =-(2.303)(8.314)(300) \\
& =-5744 \mathrm{~J} \\
& =-5.744 \mathrm{~kJ} \\
& =-57.44 \times 10^{-1} \mathrm{~kJ}
\end{aligned}
$$



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85. Number of compounds which give reaction with Hinsberg's reagent is $\qquad$ .









## Answer (5)

Sol. $1^{\circ}$ and $2^{\circ}$ amines will give reaction with Hinsberg reagent

Compound which gives reaction with Hinsberg reagent are
(1) $\mathrm{Ph}-\mathrm{NH}_{2}$
(2)

(3) $\mathrm{NH}_{2}-\mathrm{CH}_{2}-\mathrm{CH}_{2}-\mathrm{NH}_{2}$
(4)

(5) $\mathrm{CH}_{3}-\mathrm{CH}_{2}-\mathrm{CH}_{2}-\mathrm{NH}_{2}$
86. The amount of electricity in Coulomb required for the oxidation of 1 mol of $\mathrm{H}_{2} \mathrm{O}$ to $\mathrm{O}_{2}$ is $\qquad$ $\times 10^{5} \mathrm{C}$.

## Answer (2)

Sol. $2 \mathrm{H}_{2} \mathrm{O} \longrightarrow \mathrm{O}_{2}+4 \mathrm{H}^{+}+4 \mathrm{e}^{-}$
Mole of electron $=2$
Charge $=2 \times 96500 \mathrm{C}$

$$
=1.93 \times 10^{5} \mathrm{C}
$$

Nearest integer $=2$
87. Total number of isomeric compounds (including stereoisomers) formed by monochlorination of 2-methylbutane is $\qquad$ .

## Answer (6)

Sol. 4 structural isomers are obtained out of which 2 are optically active.
$\Rightarrow$ Total 6 isomers are obtained.
88. The number of tripeptides formed by three different amino acids using each amino acid once is $\qquad$ .

## Answer (6)

Sol.


Answer $=3 \times 2 \times 1$

$$
=6
$$

89. Mass of ethylene glycol (antifreeze) to be added to 18.6 kg of water to protect the freezing point at $-24^{\circ} \mathrm{C}$ is $\qquad$ kg (Molar mass in $\mathrm{g} \mathrm{mol}^{-1}$ for ethylene glycol $62, \mathrm{~K}_{\mathrm{f}}$ of water $=1.86 \mathrm{~K} \mathrm{~kg} \mathrm{~mol}^{-1}$ )

Answer (15)
Sol. $\Delta \mathrm{T}_{\mathrm{f}}=\mathrm{K}_{\mathrm{f}}(\mathrm{m})$

$$
24=1.86 \times \frac{\text { moles }}{18.6}
$$

Moles $=240$
Mass $=240 \times 62$
$=14880 \mathrm{gm}$
$=14.88 \mathrm{~kg}$
Nearest integer $=15$


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90. The following data were obtained during the first order thermal decomposition of a gas $A$ at constant volume :
$\mathrm{A}(\mathrm{g}) \rightarrow 2 \mathrm{~B}(\mathrm{~g})+\mathrm{C}(\mathrm{g})$

| S.No. | Time/s | Total pressure/(atm) |
| :--- | :--- | :--- |
| 1. | 0 | 0.1 |
| 2. | 115 | 0.28 |

The rate constant of the reaction is $\qquad$ $\times 10^{-2} \mathrm{~s}^{-1}$ (nearest integer)

## Answer (2)

Sol. $K=\frac{2.303}{115} \log \left(\frac{0.3-0.1}{0.3-0.28}\right)$

$$
\begin{aligned}
\mathrm{K} & =\frac{2.303}{115} \log \left(\frac{0.2}{0.02}\right) \\
& =\frac{2.303}{115} \log 10 \\
& =\frac{2.303}{115} \\
& =0.02002 \\
& =2 \times 10^{-2} \mathrm{sec}^{-1}
\end{aligned}
$$

Answer $=2$


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