24/01/2026
MORNING

Memory Based Answers & Solutions

for

JEE (Main)-2026 (Online) Phase-1

(Mathematics and Physics, Chemistry)

Time : 3 hrs. M.M. : 300

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.

(3) This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.

(4) **Section - A :** Attempt all questions.

(5) **Section - B :** Attempt all questions.

(6) **Section - A (01 – 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

(7) **Section - B (21 – 25) contains** 5 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

1. $\lim\limits_{x\to 0}\dfrac{e^x\left(e^{\tan x-x}-1\right)+\ell n\left(\sec x+\tan x\right)-x}{(\tan x-x)}$

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

(3) $\frac{5}{2}e$ (4) $\frac{5}{2}$

Ans. **(1)**

Sol. $\lim\limits_{x\to 0}\dfrac{e^{\tan x}-e^x+\ell n\left(\sec x+\tan x\right)-x}{\tan x-x}$

Applying L'hospital rule

$\Rightarrow \lim\limits_{x\to 0}\dfrac{e^{\tan x}.\sec^2 x-e^x+\sec x-1}{\sec^2 x-1}$

$\lim\limits_{x\to 0}\dfrac{e^{\tan x}(\sec^2 x-1)+(e^{\tan x}-e^x)+\sec x-1}{\tan^2 x}$

$\lim\limits_{x\to 0}\left(e^{\tan x}+\dfrac{e^x\left(e^{\tan x-x}-1\right)}{\tan^2 x}+\dfrac{1}{\sec x+1}\right)$

$\Rightarrow 1+0+\frac{1}{2}=\frac{3}{2}$

2. z is a complex number satisfying

$\left|\dfrac{z-6i}{z-2i}\right|=1$ and $\left|\dfrac{z-8+2i}{z+2i}\right|=\dfrac{3}{5}$

then $\Sigma|z|^2$ is

(1) 225 (2) 321

(3) 284 (4) 385

Ans. **(4)**

Sol. Solving $\left|\dfrac{z-6i}{z-2i}\right|=1\Rightarrow y=4$ ..... (1)

(where z = x + iy)

Now solving $\left|\dfrac{z-8+2i}{z+2i}\right|=\dfrac{3}{5}$

$\Rightarrow x^2+y^2-25x+4y+104=0$ .... (2)

Solving (1) & (2) $\Rightarrow z = 17 + 4i$ & $8 + 4i$

$\Rightarrow \Sigma|z|^2=(17)^2+(4)^2+(8)^2+(4)^2=385$

3. There are 10 defective & 90 non-defective balls in a bag. 8 balls are taken one by one with replacement then probability that at least 7 defective balls are selected.

(1) $\left(\frac{73}{10^8}\right)$ (2) $\left(\frac{37}{10^8}\right)$

(3) $\left(\frac{105}{10^8}\right)$ (4) $\left(\frac{11}{10^8}\right)$

Ans. **(1)**

Sol. 10 defective & 90 non-defective

Req. probability = (7 def 1 fair) or (8 defective)

Req. probability $=\dfrac{\left(10^7\times 90\right)\times 8+10^8}{100^8}$

$=\dfrac{72\times 10^8+10^8}{100^8}=\dfrac{73}{10^8}$

4. Let $f(x)=\int\dfrac{1-\sin(\ell nt)}{1-\cos(\ell nt)}dt$ and $f\left(e^{\pi/2}\right)=-e^{\frac{\pi}{2}}$

then $f\left(e^{\frac{\pi}{4}}\right)$ is :

(1) $e^{-\frac{\pi}{4}}\left(\sqrt{2}+1\right)$ (2) $-e^{\frac{\pi}{4}}\left(\sqrt{2}+1\right)$

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

Ans. **(2)**

Sol. $f(t)=\int\dfrac{1-\sin(\ln t)}{1-\cos(\ln t)}dt$

Let $\ln t = x \Rightarrow t = e^x \Rightarrow dt = e^x dx$

$=\frac{1}{2}\int\left(\text{cosec}^2\frac{x}{2}-2\cot\frac{x}{2}\right)e^x dx-t\cot\left(\frac{\ln t}{2}\right)+C$

$\left(\therefore\int(f(x)+f'(x))e^x dx=f(x).e^x+c\right)$

Now $f\left(e^{\pi/2}\right)=-e^{\pi/2}\cot\left(\frac{\pi}{4}\right)+C=-e^{\frac{\pi}{2}}$ (given)

$\Rightarrow C = 0$

Now $f\left(e^{\pi/4}\right)=-e^{\pi/4}\cot\left(\frac{\pi}{8}\right)+C=-e^{\frac{\pi}{4}}(\sqrt{2}+1)$

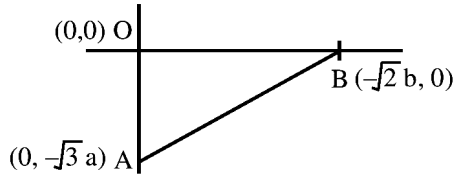
5. Given triangle OAB where O is the origin, $A=\left(0,-\sqrt{3}a\right)$ & $B\left(-\sqrt{2}b,0\right)$ let the circumradius of ΔOAB is 4 units. If the locus of the centroid of ΔOAB is a circle then its radius is :

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

(3) $\frac{11}{3}$ (4) $\frac{5}{3}$

Ans. **(1)**

Sol.



$$4 = \frac{\sqrt{2b^2 + 3a^2}}{2}$$

$$2b^2 + 3a^2 = 8^2$$

$$(h, k) = \left(\frac{-\sqrt{2}\,b}{3}, \frac{-\sqrt{3}a}{3}\right)$$

$$b = \frac{3h}{-12}, \quad a = \frac{3k}{-\sqrt{3}}$$

$$2b^2 + 3a^2 = 64$$

$$9h^2 + 9k^2 = 64 \Rightarrow x^2 + y^2 = \left(\frac{8}{3}\right)^2$$

$$r = \frac{8}{3}$$

6. Let the lines $L_2 : \vec{r} = \left(\hat{i} + 2\hat{j} + 3\hat{k}\right) + \lambda\left(2\hat{i} + 3\hat{j} + 4\hat{k}\right)$, $\lambda \in R$ and $L_2 : \vec{r} = \left(4\hat{i} + \hat{j}\right) + \mu\left(5\hat{i} + 2\hat{j} + \hat{k}\right)$, $\mu \in R$ intersect at the point R. Let P and Q be the points lying on the line L_1 & L_2 respectively. Such that $|PR| = \sqrt{29}$ and $|PQ| = \sqrt{\frac{47}{3}}$. If the point P lies is the first octant then 27 $(QR)^2$ is :

(1) 340 (2) 360

(3) 320 (4) 348

Ans. (2)

Sol. For POI

$2\lambda + 1 = 5\mu + 4$; $3\lambda + 2 = 2\mu + 1$; $4\lambda + 3 = \mu$

$\Rightarrow \lambda = \mu = -1$

R(–1, –1, –1) P($2\lambda + 1, 3\lambda + 2, 4\lambda + 3$)

$PR^2 = 29 \Rightarrow (2\lambda + 2)^2 + (3\lambda + 3)^2 + (4\lambda + 4)^2 = 29$

$\Rightarrow \lambda = 0$ or $\lambda = -2$ (Reject)

$\Rightarrow$ P (1, 2, 3)

Q ($5\mu + 4, 2\mu + 1, \mu$)

$$|PQ| = \sqrt{\frac{47}{3}} \Rightarrow PQ^2 = \frac{47}{3}$$

$$\Rightarrow (5\mu + 3)^2 + (2\mu - 1)^2 + (\mu - 3)^2 = \frac{47}{3}$$

$$\Rightarrow \mu = -\frac{1}{3}$$

$$Q = \left(\frac{7}{3}, \frac{1}{3}, -\frac{1}{3}\right)$$

$$(QR)^2 = \left(\frac{7}{3} + 1\right)^2 + \left(\frac{1}{3} + 1\right)^2 + \left(-\frac{1}{3} + 1\right)^2$$

$$= \frac{100 + 16 + 4}{9} = \frac{120}{9}$$

$$\Rightarrow 27 \times (QR)^2 = 27 \times \frac{120}{9} = 360$$

7. If A={1, 2, 3, 4}. A relation from set A to A (a,b) R (c, d) such that 2a + 3b = 3c + 4d, then find the number of element(s) in relation :

(1) 9 (2) 10

(3) 11 (4) 12

Ans. (3)

Sol.

(a, b)	(c, d)
(1, 1)	x
(1, 2)	x
(1, 3)	(1, 2)
(1, 4)	(2, 2)
(2, 1)	(1, 1)
(2, 2)	(2, 1)
(2, 3)	(3, 1)
(2, 4)	(4, 1)
(3, 1)	x
(3, 2)	x
(3, 3)	(1, 3)
(3, 4)	(2, 3)
(4, 1)	(1, 2)
(4, 2)	(2, 2)
(4, 3)	x
(4, 4)	(4, 2)

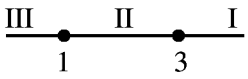
8. Find the number of real solutions of $x|x-3| + |x-1| + 3 = 0$:

(1) 1 (2) 2

(3) 3 (4) 4

Ans. (1)

Sol.



(I) if $x \geq 3$

$\therefore x^2 - 3x + x - 1 + 3 = 0$

$\therefore x^2 - 2x + 2 = 0$

No real solution

(ii) If $1 < x < 3$

$\therefore 3x - x^2 + x - 1 + 3 = 0$

$\Rightarrow x^2 - 4x - 2 = 0$

$\rightarrow x = \frac{4 \pm \sqrt{16+8}}{2} = \frac{4 \pm \sqrt{24}}{2} = 2 \pm \sqrt{6}$

(III) If $x \le 1$

$\therefore\ 3x - x^2 + 1 - x + 3 = 0$

$\Rightarrow x^2 - 2x - 4 = 0 \rightarrow x = \frac{2 \pm \sqrt{4+16}}{2} = 1 \pm \sqrt{5}$

So, total 1 real solution

If $\cot x = \frac{5}{12}$ for some $x \in \left(\pi, \frac{3\pi}{2}\right)$ then

$\left(\cos\frac{13x}{2} + \sin\frac{13x}{2}\right) + \cos 7x\left(\cos\frac{13x}{2} - \sin\frac{13x}{2}\right)$ is equal to :

(1) $\frac{1}{\sqrt{13}}$ (2) $\frac{5}{\sqrt{13}}$

(3) $-\frac{1}{\sqrt{13}}$ (4) $\frac{8}{\sqrt{13}}$

(1)

Sol. $\cot x = \frac{5}{12} \Rightarrow \cos x = \frac{-5}{13} = 2\cos^2\frac{x}{2} - 1$

$\cos\left(\frac{x}{2}\right) = -\frac{2}{\sqrt{13}}$ or $\frac{2}{\sqrt{13}}$(rejected)

$\left\{\because \frac{x}{2} \in \left(\frac{\pi}{2}, \frac{3\pi}{4}\right)\right\}$

$\left(\sin 7x\frac{\sin 13x}{2} + \cos 7x\frac{\cos 13x}{2}\right) + \left(\sin 7x\frac{\cos 13x}{2} - \cos 7x\frac{\sin 13x}{2}\right)$

$\cos\left(7x - \frac{13x}{2}\right) + \sin\left(7x - \frac{13x}{2}\right)$

$\cos\frac{x}{2} + \sin\left(\frac{x}{2}\right)$

$\frac{3}{\sqrt{13}} - \frac{2}{\sqrt{13}} = \frac{1}{\sqrt{13}}$

10. Consider an ellipse $E_1 : \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ (a > b) and $E_2 : \frac{x^2}{A^2} + \frac{y^2}{B^2} = 1$ (B > A) where $e = \frac{4}{5}$ for both the curves and ℓ_1 is the length of latus rectum of E_1 and ℓ_2 is the length of latus rectum of E_2. Let the distance between the focii of the first curve is 8. Find the distance between the focii of the second curve (Given $\left(2\ell_1^2 = 9\ell_2\right)$) :

(1) $\frac{64}{5}$ (2) $\frac{8}{5}$

(3) $\frac{32}{5}$ (4) $\frac{16}{5}$

Ans. (3)

Sol. $2ae = 8 \Rightarrow a = 5$

$b^2 = a^2(1 - e^2)$

$b^2 = a^2 \times \frac{9}{25}$ $b^2 = 9$

$E_1 : \frac{x^2}{25} + \frac{y^2}{9} = 1$

$\ell_1 : \frac{2b^2}{a} = \frac{2\times 9}{5} = \frac{18}{5}$

$A^2 = B^2\left(1 - e^2\right) \Rightarrow A^2 = \frac{9}{25}B^2 \Rightarrow A = \frac{3}{5}B$

$2\ell^2 = 9\ell_2 \Rightarrow 2\left(\frac{18}{5}\right)^2 = 9\ell_2 \Rightarrow \ell_2 = \frac{4\times 18}{25}$

$\frac{2A^2}{B} = \frac{72}{25} \Rightarrow A^2\frac{36}{25}B$

$\frac{9}{25}B^2 = \frac{36B}{25} \Rightarrow B = 4,$

Distance between focii 2Be = $2 \times \frac{4}{5} \times 4 = \frac{32}{5}$

11. Let mean & variance of 10 numbers are 10 & 2 respectively. If one number α is replaced by another number β, then new mean & variance are 10.1 & 1.99. Find $(\alpha + \beta)$

(1) 20 (2) 19

(3) 18 (4) 17

Ans. (1)

Sol. Let first 10 numbers are $x_1, x_2, \ldots\ldots x_9, \alpha$

$\Rightarrow \alpha + \sum_{i=1}^{9} x_i = 100 \Rightarrow \sum_{i=1}^{9} x_i = 100 - \alpha$

Variance = $\left(\frac{\sum x_i^2}{n}\right) - \left(\frac{\sum x_i}{n}\right)^2$

$\Rightarrow \frac{\sum x_i^2}{n} = 98$

$\Rightarrow x_1^2 + x_2^2 + \ldots\ldots x_9^2 + \alpha^2 = 1020 \Rightarrow \sum x_i^2 = 1020 - \alpha^2$

In second case, let number are

$x_1, x_2, \ldots\ldots x_9, \beta$

$100 - \alpha + \beta = 101$ $\alpha - \beta + 1 = 0$

$\frac{\sum x_i^2 + \beta^2}{10} - (10.1)^2 = 1.99$

$\beta^2 - \alpha^2 = 20$

$\alpha = \frac{19}{2}$

$$\beta = \frac{21}{2}$$

$$\alpha + \beta = \frac{19+21}{2} = 20$$

12. The value of $\frac{\sqrt{3}\ \text{cosec}20° - \sec 20°}{\cos 20° \cos 40° \cos 60° \cos 80°}$ is :

(1) 64 (2) 48

(3) 46 (4) 40

Ans. **(1)**

Sol. $$E = \frac{\frac{\sqrt{3}}{\sin 20°} - \frac{1}{\cos 20°}}{\frac{1}{2}.\frac{1}{4}.\cos 60°}$$

$$= \frac{\left(\sqrt{3}\cos 20° - \sin 20°\right)}{\cos 20°.\sin 20°} 16$$

$$= \frac{\left(\frac{\sqrt{3}}{2}\cos 20° - \frac{1}{2}\sin 20°\right) 32 \times 2}{2\cos 20°.\sin 20°}$$

$$= \frac{\sin 40°}{\sin 40°} \times 64 = 64$$

13. Find number of matrices A whose order is 3 × 2 has elements from the set $\{\pm 2, \pm 1, 0\}$ if $\text{Tr}(A^TA) = 5$:

(1) 310 (2) 312

(3) 320 (4) 325

Ans. **(2)**

Sol. $$\begin{pmatrix} a_1 & b_1 \\ a_2 & b_2 \\ a_3 & b_3 \end{pmatrix}_{3\times 2}$$

$$A^TA = \begin{pmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{pmatrix}_{2\times 3} \begin{pmatrix} a_1 & b_1 \\ a_2 & b_2 \\ a_3 & b_3 \end{pmatrix}_{3\times 2}$$

$$= \begin{pmatrix} a_1^2 + a_2^2 + a_3^2 & \\ & b_1^2 + b_2^2 + b_3^2 \end{pmatrix}$$

$$\text{Tr}\,(A^TA) = a_1^2 + a_2^2 + a_3^2 + b_1^2 + b_2^2 + b_3^2 = 5$$

$\{2, 1, 0, 0, 0, 0\}$

$\{2, -1, 0, 0, 0, 0\}$

$\{-2, 1, 0, 0, 0, 0\}$

$\{-2, -1, 0, 0, 0, 0\}$

$\{1, 1, 1, 1, 1, 0\}$

$$\text{No. of ways} = \frac{6!}{4!} \times 4 + 2 \times \frac{6!}{5!} + 2 \times \frac{6!}{4!} + 2 \times \frac{6!}{3!2!}$$

$$= \frac{6!}{3!} + 2 \times 6 + 2 \times 15 \times 2 \times \frac{6!}{3!}$$

$$= 120 + 120 + 12 + 60 = 312$$

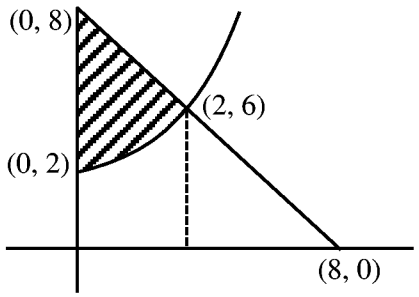
14. A_1 is the area bounded by $y = x^2 + 2$, $x + y = 8$, y-axis in the 1st quadrant and A_2 is the area bounded by $y = x^2 + 2$, $y^2 = x$, $x = 0$ and $x = 2$ in the 1st quadrant find $(A_1 - A_2)$:

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

(3) $\frac{3}{5} + \frac{4\sqrt{2}}{3}$ (4) None of these

Ans. **(1)**

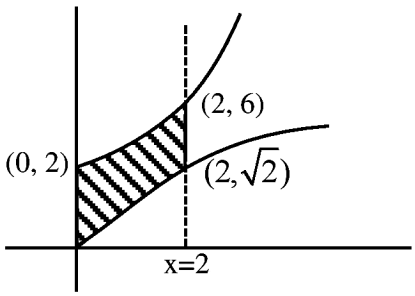
Sol.



$$A_1 = \int_0^2 ((8 - x) - (x^2 + 2))\, dx$$

$$= A_1 = \int_0^2 (6 - x - x^2)\, dx$$

$$A_1 \left(6x - \frac{x^2}{2} - \frac{x^3}{3}\right)_0^2 = 12 - 2 - \frac{8}{3} = 10 - \frac{8}{3} = \frac{22}{3}$$



$$A_2 = \int_0^2 (x^2 + 2)dx - \frac{2}{3}(2\sqrt{2})$$

$$A_2 = \left(\frac{x^3}{3} + 2x\right)_0^2 - \frac{4\sqrt{2}}{3}$$

$$A_2 = \frac{8}{3} + 4 - \frac{4\sqrt{2}}{3} = \frac{20}{3} - \frac{4\sqrt{2}}{3}$$

$$A_1 - A_2 = \frac{2}{3} + \frac{4\sqrt{2}}{3}$$

15. Evaluate the series

$$\frac{1}{25!} + \frac{1}{3!23!} + \frac{1}{5!21!} + \ldots\ldots + \text{upto 13 terms} :$$

(1) $\frac{2^{26}}{26!}$ (2) $\frac{2^{25}}{26!}$

(3) $\frac{2^{26}}{25!}$ (4) $\frac{2^{25}}{25!}$

Ans. (2)

Sol. $\frac{1}{26!}\left(\frac{26!}{25!1!}+\frac{26!}{3!23!}+\frac{26!}{5!21!}+.....+13 \text{ terms}\right)$

$\frac{1}{26!}\left({}^{26}C_1+{}^{26}C_3+{}^{26}C_5+....+13\text{terms}\right)$

$\frac{1}{26!}\left({}^{26}C_1+{}^{26}C_5+....+{}^{26}C_{25}\right)$

$\frac{1}{26!}\times 2^{25}$

16. Consider a geometric sequence 729, 81, 9, 1, …… If P_n denotes the product of Ist n terms of G.P. such that $\sum_{n=1}^{40}(P_n)^{\frac{1}{n}}=\frac{3^{\alpha}-1}{2\times 3^{\beta}}$, then value of $(\alpha+\beta)$ is :

(1) 72 (2) 74

(3) 73 (4) 75

Ans. (3)

Sol. $P_n = 729.81.9$ ……(n terms)

$= 3^6.3^4.3^2$ …….. 3^{-2n+8}

$P_n = 3^{6+4+2+.....+(-2n+8)} = 3^{n(7-n)}$

$P_n^{1/n} = 3^{7-n}$

$\Rightarrow \sum_{n=1}^{40}(P_n)^{\frac{1}{n}} = 3^6+3^5+.....+(40\text{terms})$

$=3^6\left[\frac{1-\left(\frac{1}{3}\right)^{40}}{1-\frac{1}{3}}\right]$

$=\frac{3^6\left[3^{40}-1\right]\times 3^1}{3^{40}\times 2}$

$\sum(P_n)^{\frac{1}{n}}=\frac{(3^{40}-1)}{2\times 3^{33}}$, $\alpha = 40$

$\beta = 33$

$\alpha + \beta = 73$

17. Consider an A.P. $a_1, a_2, \ldots\ldots\ldots a_n$; $a_1 > 0$, $a_2 - a_1 = \frac{-3}{4}$, $a_n = \frac{a_1}{4}$, $\sum_{i=1}^{n}a_i=\frac{525}{2}$ then $\sum_{i=1}^{17}a_i$ is equal to :

(1) 231 (2) 234

(3) 236 (4) 238

Ans. (4)

Sol. $S_n=\frac{n}{2}[a_1+a_n]=\frac{525}{2}$, $d=\frac{-3}{4}$

$\frac{n}{2}\left[a_1+\frac{a_1}{4}\right]=\frac{525}{2}$

$\frac{5a_1n}{4}=525$

$a_1n = 420$

$a_n = a_1 + (n-1)\left(\frac{-3}{4}\right)$

$\Rightarrow \frac{-3}{4}a_1=\left(\frac{-3}{4}\right)(n-1) \Rightarrow a_1 = n-1$

$n(n-1) = 420$

$n^2-n-420=0$

$(n-21)(n+20)=0$

$n = 21,\ a_1 = 20$

$\sum_{i=1}^{17}a_i=\frac{17}{2}[2a_1+16d]$

$=\frac{17}{2}\left[40+16\left(\frac{-3}{4}\right)\right]$

$=\frac{17}{2}[40-12]$

$= 17 \times 14 = 238$

18. If the domain of $f(x)=\log_{(10x^2-17x+7)}(18x^2-11x+1)$ is $(-\infty, a) \cup (b, c) \cup (d, \infty) - \{e\}$, then find $90(a+b+c+d+e)$:

(1) 316 (2) 320

(3) 163 (4) 631

Ans. (1)

Sol. $18x^2 - 11x + 1 > 0$

$(9x-1)(2x-1) > 0 \Rightarrow \boxed{x > \frac{1}{2} \text{ or } x < \frac{1}{9}}$ …..(1)

$10x^2 - 17x + 7 > 0$

$(10x-7)(x-1) > 0$

$\boxed{x > 1 \text{ or } x < \frac{7}{10}}$ ….(2)

$10x^2 - 17x + 7 > 0$

$10x^2 - 17x + 6 \neq 0$

$(5x-6)(2x-1) \neq 0$

$\boxed{x \neq \frac{6}{5}, \frac{1}{2}}$ ……(3)

Eq. (1) & (2) & (3)

$x \in \left(-\infty, \frac{1}{9}\right) \cup \left(\frac{1}{2}, \frac{7}{10}\right) \cup (1, \infty) - \left\{\frac{6}{5}\right\}$

$a = \frac{1}{9}, b = \frac{1}{2}, c = \frac{7}{10}$, d = e, 1, $e = \frac{6}{5}$

$90(9 + b + c + d + e)$

$= 316$

19. Given that $\vec{a}=2\hat{i}+\hat{j}-\hat{k}$, $\vec{b}=\hat{i}+\hat{j}$, $\vec{c}=\vec{a}\times\vec{b}$ $|\vec{d}\times\vec{c}|=3$ & $\vec{d}\,\hat{}\,\vec{c}=\frac{\pi}{4}$ & $|\vec{a}-\vec{d}|=\sqrt{11}$ find $\vec{a}.\vec{d}$

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

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

Ans. (3)

Sol. $\vec{c}=\vec{a}\times\vec{d}=\begin{vmatrix} i & j & k \\ 2 & 1 & -1 \\ 1 & 1 & 0 \end{vmatrix}=i-j+k$ .....(1)

$|\vec{d}\times\vec{c}|=|\vec{d}||\vec{c}|\sin\theta=|\vec{d}|\sqrt{3}.\frac{1}{\sqrt{2}}=3$ (given)

$\Rightarrow|\vec{d}|=\sqrt{6}$ ..... (2)

Now

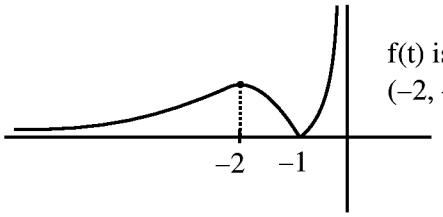
$|\vec{a}-\vec{d}|=\sqrt{11}\Rightarrow|\vec{a}|^2+|\vec{d}|^2-2\vec{a}.\vec{d}=11$

$\Rightarrow 6+6-2\vec{a}.\vec{d}=11\Rightarrow\vec{a}.\vec{d}=\frac{1}{2}$

20. Given $f(t)=\left|\frac{t+1}{t^2}\right|;(t<0)$ is strictly decreasing in the interval $(2\alpha, \alpha)$ then maximum value of $g(x) = 2\log_e(x-2) + \alpha x^2 + 4x - \alpha$ is

Ans. (4)

Sol. Drawing graph of f(t) for $t < 0$

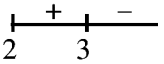


f(t) is decreasing in $(-2, -1) \Rightarrow \alpha = -1$

$g(x) = \log_e(x-2) - x^2 + 4x + 1;\quad x > 2$

$g'(x) = \frac{2}{x-2} - (2(x-2)\ ;\ x > 2$

$g'(x) = \frac{1-(x-2)^2}{(x-2)} = \frac{-(x-3)(x-1)}{(x-2)}$



as $x > 2$

maxima occur at $x = 3$

$g(3) = 2\log_e 1 - 9 + 12 + 1 = 4$

21. Let $5000 < N < 9000$ and N has digits from {0, 1, 2, 5, 9} and digits can be repeated then find the number of N divisible by 3.

Ans. (84)

Sol. 5 9 9 9 ×

0 1 = 3! = 6

2 2 = $\frac{3!}{2!}$ = 3

5 5 = $\frac{3!}{2!}$ = 3

5 2 = 3! = 6

5 5 0 2 = 3! = 6

0 5 = $\frac{3!}{2!}$ = 3

9 2 = 3! = 6

9 5 = $\frac{3!}{2!}$ = 3

5 2 0 2 = 3

0 5 = 6

9 2 = 3

9 5 = 6

5 1 0 0 = 3

2 1 = 3

5 1 = 3

9 0 = 6

5 0 0 1 = 3

2 2 = 3

5 2 = 3! = 6

5 5 = 3

Total = $8 \times 6 + 12 \times 3$

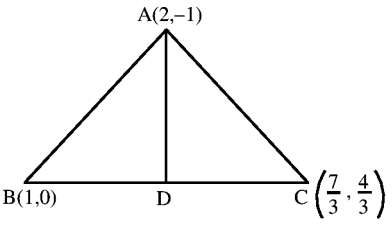
$= 48 + 36$

$= 84$

22. Let the vertices of the triangle are (1, 0), (2, –1), $\left(\frac{7}{3},\frac{4}{3}\right)$. If the equation of internal angle bisector through (2, –1) is $\alpha x + \beta y = 5$ then value of $(\alpha^2 + \beta^2)$ is:

Ans. (10)

Sol.



$$\frac{BD}{DC}=\frac{AB}{AC}=\frac{\sqrt{2}\times 3}{5\sqrt{2}}=\frac{3}{5}$$

$$D=\left(\frac{12}{8},\frac{4}{8}\right)=\left(\frac{3}{2},\frac{1}{2}\right)$$

$$\text{Slope of AD} = \frac{-3/2}{\frac{1}{2}}=-3$$

$3x + y = 5$

$\alpha = 3, \beta = 1;\ \alpha^2 + \beta^2 = 10$

23. If $\int_0^{36} f\left(\frac{tx}{36}\right)dt$ at $= 4\alpha$ f(x), y = f(x) is standard parabola passing through (2, 1) and (–4, β). Then value of β^{α} is :

Ans. (64)

Sol. $\int_0^{36} f\left(\frac{tx}{36}\right)dt = 4\alpha f(x),$ Put $\frac{tx}{36}=y$

$$\frac{dy}{dt}=\frac{x}{36}$$

$$\int_0^x \frac{f(y)36dy}{x}=4\alpha f(x)$$

$$\int_0^x f(y)dy=\frac{\alpha f(x)x}{9}$$

$$f(x)=\frac{\alpha}{9}\left(f(x)+xf'(x)\right)$$

$$\left(1-\frac{\alpha}{9}\right)f(x)=\frac{\alpha x}{9}f'(x)\Rightarrow(9-\alpha)f(x)=\alpha x f'(x)$$

$$\frac{f'(x)}{f(x)}=\left(\frac{9}{\alpha}-1\right)\frac{1}{x}$$

$$\log_e f(x)=\left(\frac{9}{\alpha}-1\right)\log_e x+\log_e c$$

$f(x)=cx^{\left(\frac{9}{\alpha}-1\right)}$ for standard parabola

$$\frac{9}{\alpha}-1=2$$

$\alpha = 3$

$f(x) = cx^2$

passing through (2,1)

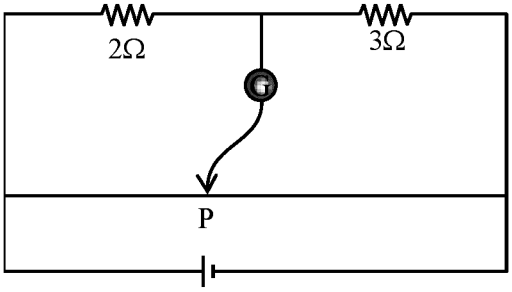
$1 = 4c \Rightarrow c = 1/4$

$y=\frac{x^2}{4}$ passing through (–4, β)

$\beta = 4$

$\beta^x = 4^3 = 64$

1. Figure shows a meter-bridge. Initially null point was achieved at point P as shown in the figure.



When an unknown resistance "R" is connected in parallel with 3Ω the null point was shifted by 22.5 cm. Then the value of unknown resistance is :

(1) 2Ω (2) 3Ω

(3) 2.5 Ω (4) 5Ω

Ans. **(1)**

Sol. Initially , $\frac{2}{3}=\frac{40}{60}$

Now when 'R' connected in parallel

$$\frac{2}{\frac{3R}{3+R}}=\frac{40+22.5}{60-22.5}=\frac{62.5}{37.5}$$

$\therefore R = 2\Omega$

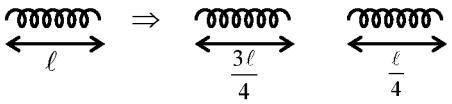
2. A spring of spring constant K = 15 N/m is cut into two parts of ratio of length 3 : 1. Find the spring constant of spring with smaller length (in N/m).

(1) 60 (2) 40

(3) 30 (4) 70

Ans. **(1)**

Sol.



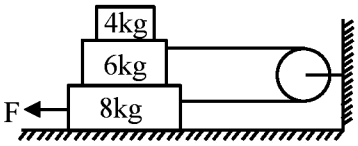
$K\ell$ = constant

$$K\ell = K'\left(\frac{\ell}{4}\right)$$

K' = 4 K

K' = 60 N/m

3. Figure shows three block with masses 8kg, 6kg and 4 kg. Friction coefficient between each surface is $\frac{1}{2}$. The maximum value of force 'F' such that 8kg block moves with constant velocity will be :

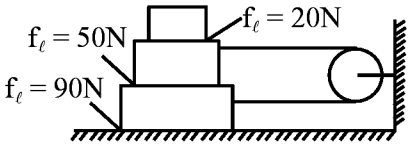


(1) 210 N (2) 400 N

(3) 110 N (4) 300 N

Ans. **(1)**

Sol. For 8kg to move with constant velocity $F_{net} = 0$.

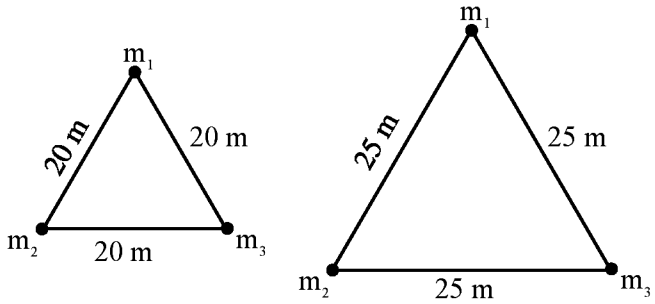


$\therefore$ F = 90 + T + 50 (for 8kg block)

T = 20 + 50 (for 6kg block)

$\therefore$ F = 210 N.

4. Three masses m_1 = 200 kg, m_2 = 300 kg and m_3 = 400 kg are kept at the vertices of on equilateral triangle of side 20 m. If the masses are shifted to new configuration such that they are at the vertices of an equilateral triangle of 25 m now. Find the work done in this process :



(1) 1.735×10^{-7} J (2) 17.35×10^{-7} J

(3) 173.5×10^{-7} J (4) 1735×10^{-7} J

Ans. **(1)**

Sol. Work done by external agent :

$w_{ext} = \Delta U$

$$U_i = \frac{Gm_1m_2}{r_i} + \frac{Gm_2m_3}{r_i} + \frac{Gm_1m_3}{r_i} \quad : r_i = 20 \text{ m}$$

$$U_f = \frac{Gm_1m_2}{r_f} + \frac{Gm_2m_3}{r_f} + \frac{Gm_1m_3}{r_f} \quad : r_f = 25 \text{ m}$$

$$U_i = \frac{-6.67\times10^{-11}}{20} [200\times300+300\times400+200\times400]$$

$$= \frac{-6.67\times10^{-11}}{20}\times26\times10^4 = -86.71 \times 10^{-8} \text{ J}$$

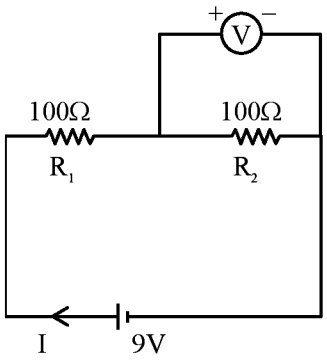
$$U_f = \frac{-6.67\times10^{-11}}{0.25} [200\times300+300\times400+200\times400]$$

$$= \frac{-6.67\times10^{-11}}{0.25}\times26\times10^4 = -693.68 \times 10^{-9}$$

$= -69.36 \times 10^{-8}$ J $W = +\Delta U = 17.35 \times 10^{-8}$

$= 1.735 \times 10^{-7}$ J

5. Two resistors of resistances $R_1 = 100\Omega$ and $R_2 = 100\Omega$ are connected in series. A voltmeter of resistance 400Ω is connected in parallel to one of the resistance. Find the reading of voltmeter. The emf of battery is 9V. :



(1) 3 V (2) 4 V

(3) 2 V (4) 5 V

Ans. (2)

Sol. Current in circuit.

$$I = \frac{E}{Req}$$

$$Req = 100 + \frac{400\times100}{500} = 180\Omega$$

$$\therefore I = \frac{9}{180} = \frac{1}{20} A$$

Reading of voltmeter = $V = I \times 80 = \frac{1}{20}\times80 = 4V$

6. A brass rod is fixed rigidly at two ends at 27°C. If it is cooled to temperature –43°C, tension in rod becomes T_0. Find temperature (in °C) at which tension will be 1.4 T_0 :

Ans. –71°C

Sol. Thermal stress causes tension

$T = \alpha yA\Delta T$

–43°C $T_0 = \alpha yA(43 + 27)$ .....(i)

–t°C $T_0 = \alpha yA(t + 27)$ .....(ii)

(ii)/(i)

$$1.4 = \frac{t+27}{70}$$

$t + 27 = 98$

$t = 71°$

$\therefore$ temp (–71°C)

7. Electric potential at a point is $V = Ar^3 + B$. Find charge enclosed in a sphere of radius 1m, centered at r = 0

(1) $-4\varepsilon_0 A$ (2) $-8\varepsilon_0 A$

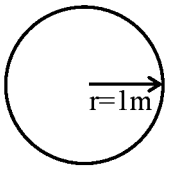
(3) $-12\varepsilon_0 A$ (4) $-16\varepsilon_0 A$

Ans. (3)

Sol. $E = -\frac{dv}{dr}$

$E = -3Ar^2$

Charge enclosed in 1m radius is



Applying guass law

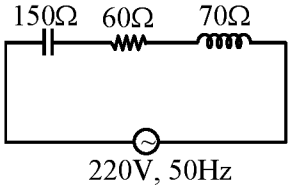
$$\oint \varepsilon.ds = \frac{q_{in}}{\varepsilon_0}$$

$$E.S = \frac{q_{in}}{\varepsilon_0}$$

$q_{in} = .\varepsilon_0 ES = -\varepsilon_0.(3Ar^2)\ (4\pi r^2)$

$q_{in})_{r=1m} = -12\varepsilon_0 A$

8. Figure shows a circuit consisting capacitor, inductor and a resistor connected in series with an AC source. Find the power factor of the circuit.



(1) 0.2 (2) 0.4

(3) 0.6 (4) 0.8

Ans. **(3)**

Sol. Power factor = $\frac{R}{Z}$

$$Z=\sqrt{R^2+(X_L-X_C)^2}$$

$$=\sqrt{60^2+(150-70)^2}=100\Omega$$

$$\therefore \text{ Power factor} = \frac{60}{100}=0.6$$

9. Following are two lists, list-I contains the types of electromagnetic waves and list-II contains theirs source. Match the entries from list-I to appropriate entries from list-II.

	List-I		List-II
(a)	x-rays	(p)	Hot bodies and molecules
(b)	Infrared rays	(q)	Oscillatory current in antennas
(c)	Microwaves	(r)	Magnetron
(d)	Radio waves	(s)	Fast moving electrons striking a metal plate

(1) (a)→(r), (b)→(q), (c)→(s), (d)→(q)

(2) (a)→(p), (b)→(s), (c)→(r), (d)→(q)

(3) (a)→(s), (b)→(p), (c)→(q), (d)→(s)

(4) (a)→(s), (b)→(p), (c)→(r), (d)→(q)

Ans. **(4)**

Sol.

10. Terminal velocity of drop of radius 1 cm is 10 cm/sec. 64 such balls are combined to make a large drop. Find terminal velocity of this larger drop. :

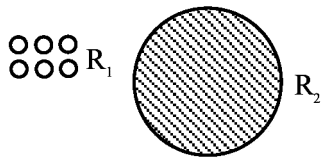
(1) 160 cm/sec (2) 140 cm/sec

(3) 180 cm/sec (4) 150 cm/sec

Ans. **(1)**

Sol. $V_T=\frac{2r^2g}{9n}[\sigma-\rho]$

$V_T \propto r^2$



64 drop

$$64\left(\frac{4}{3}\pi R_1^3\right)=\frac{4}{3}\pi R_2^3$$

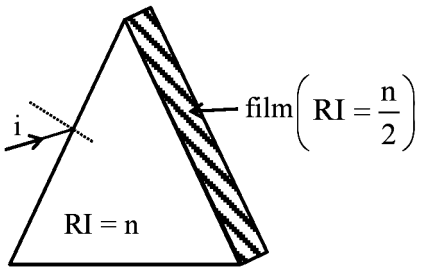
$R_2 = 4R_1$

$$\frac{(V_T)_1}{(V_T)_2}=\left(\frac{R_1}{R_2}\right)^2=\left(\frac{1}{4}\right)^2$$

$$\frac{10}{(V_T)_2}=\frac{1}{16}$$

$(V_T)_2$ = 160 cm/sec

11. Light is incident at such an angle so that minimum deviation takes place. Now a film of refractive index $\left(RI=\frac{n}{2}\right)$ is stick on other face such that total internal reflection takes place on second surface. Find angle of prism :

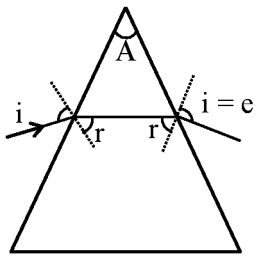


(1) 60° (2) 50°

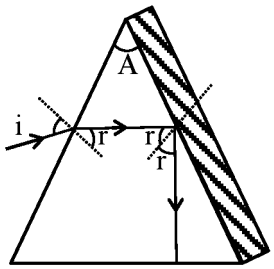
(3) 90° (4) 30°

Ans. **(1)**

Sol. i = e & r = A/2 for minimum deviation



For TIR ; $r > \theta_c$



$\text{Sin } r > \text{Sin } \theta_c$

$\text{Sin } r > \dfrac{n/2}{n}$

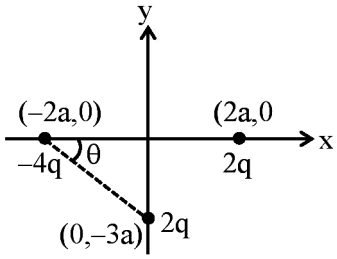
$\text{Sin } r > \dfrac{1}{2}$

$\text{Sin } \dfrac{A}{2} > \sin 30°$

$\dfrac{A}{2} > 30°$

$A > 60°$

12. In the following configuration of charges. Find the net dipole moment of the system :



(1) $\sqrt{180}\,qa$

(2) $\sqrt{150}\,qa$

(3) $\sqrt{200}\,qa$

(4) $\sqrt{140}\,qa$

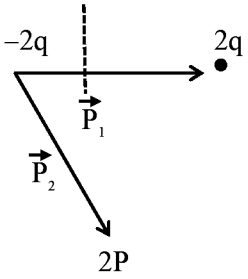
Ans. (1)

Sol. $\vec{P}_1 = (2q)(4a)\hat{i} = 8qa\hat{i}$

$\vec{P}_2 = (2q)(\sqrt{13}a)(\cos\theta\hat{i} - \sin\theta\hat{j})$

$= (3q)(\sqrt{3}a)(\cos\theta\hat{i} - \sin\theta\hat{j})$

$= (3q)(\sqrt{3}a)\left(\dfrac{2}{\sqrt{13}}\hat{i} - \dfrac{3}{\sqrt{3}}\hat{j}\right)$



$= 2qa(2\hat{i} - 3\hat{j})$ $\quad \cos\theta = \dfrac{2}{\sqrt{13}}$

$= 4qa\hat{i} - 6qa\hat{j}$ $\quad \sin\theta = \dfrac{3}{\sqrt{13}}$

$\vec{P}_{-net} = \vec{p}_1 + \vec{p}_2$ -

$= 12qa\hat{i} - 6qa\hat{j}$

$|\vec{p}_{-net}| = \sqrt{180}\,qa$

13. Density of water at 4°C is 1000 kg/m^3 and at 20°C it is 998 kg/m^3. If 4kg of water is heated from 4°C to 20°C, the change in internal energy of water is : (Given : specific heat capacity of water = 4200 J/kg).

(1) 268799.2 J (2) 268800.8 J

(3) 268800.0 J (4) 267765.2 J

Ans. (1)

Sol. $Q = mS\Delta T = 4 \times 4200 \times 16\ J = 268800\ J$

$W = P\Delta V$

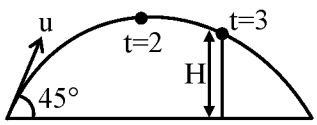
$\Delta V = \left(\dfrac{m}{\rho_f} - \dfrac{m}{\rho_i}\right) = 4\left[\dfrac{1}{998} - \dfrac{1}{1000}\right]$

$P = 10^5$ Pa.

$\therefore\ W = 10^5 \times 4 \times \left[\dfrac{1}{998} - \dfrac{1}{1000}\right] = \dfrac{8 \times 10^5}{10^3 \times 998} \approx 0.8\ J$

$\Delta U = Q - W = 268799.2\ J$

14. A projectile is projected with certain speed at an angle of 45° with horizontal as shown. At t = 2s, projectile is at maximum height and at t = 3s, it just touches a wall at a height H above horizontal. Find H in meters :

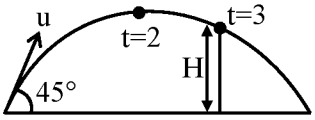


(1) 20 m (2) 10 m

(3) 15 m (4) 25 m

Ans. (3)

Sol. $T = \frac{2u_y}{g} = 4$



$\Rightarrow u_y = \frac{40}{2} = 20$ m/s

$u_x = 20$ m/s

$\Delta y = u_y \Delta t - \frac{1}{2} g(\Delta t)^2$

$\Rightarrow H = 20 \times 3 - 5 \times 9$

$= 60 - 45$

$= 15$ m

15. Column-I gives physical quantities and Column-II represent their dimensions. Choose the option representing correct matching.

Column-I			Column-II
(I)	Magnetic field intensity	(P)	$MLT^{-2}A^{-2}$
(II)	Magnetic flux	(Q)	$ML^2T^{-2}A^{-2}$
(III)	Magnetic permeability	(R)	$ML^2T^{-2}A^{-1}$
(IV)	Magnetic inductance	(S)	$MT^{-2}A^{-1}$

(1) I-S, II-R, III-P, IV-Q (2) I-Q, II-R, III-P, IV-S

(3) I-R, II-S, III-P, IV-Q (4) I-S, II-P, III-R, IV-Q

Ans. (1)

Sol. Magnetic field intensity, $B = [MT^{-2}A^{-1}]$ – S

Magnetic Flux, $\phi = [ML^2T^{-2}A^{-1}]$ – R

Magnetic Permeability, $\mu = [MLT^{-2}A^{-2}]$ – P

Magnetic inductance, $L = [ML^2T^{-2}A^{-1}]$ – Q

16. A cylindrical body of mass m and cross section A is floating in a liquid of density ρ_L such that its axis is vertical. If body is displaced by a small displacement 'x' vertically, find the time period of oscillation of the body :

(1) $2\pi\sqrt{\frac{m}{\rho_L Ag}}$ (2) $3\pi\sqrt{\frac{m}{\rho_L Ag}}$

(3) $4\pi\sqrt{\frac{m}{\rho_L Ag}}$ (4) $5\pi\sqrt{\frac{m}{\rho_L Ag}}$

Ans. (1)

Sol. $\rho_L A \times hg = mg$

After displacing by x,

$F = \rho_L A (h + x) g - mg$

$F = \rho_L Ahg + \rho_L Axg - mg$

$F = \rho_L Axg$

$a = \left(\frac{\rho_L Ag}{m}\right)x$

comparing,

$a = \omega^2 x$

$\omega = \sqrt{\frac{\rho_L Ag}{m}}$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{\rho_L Ag}}$

17. A zener diode of breakdown voltage 10 V is connected to an external voltage of 15 V and a resistance R in series. If power of zener diode is 0.4 W. Find value of unknown resistance R :

(1) 125 Ω

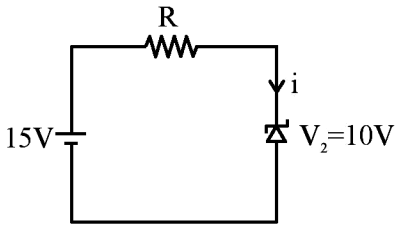
(2) 105 Ω

(3) 130 Ω

(4) 115 Ω

Ans. (1)

Sol.

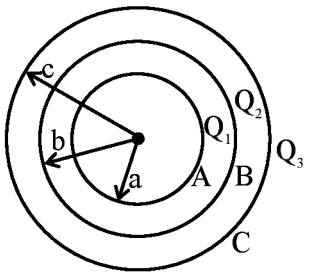


$P_D = 0.4w = 10i$

$i = 0.04A$

$R = \frac{15 - 10}{0.04} = \frac{5}{0.04} = 125\ \Omega$

18. Three uniformly charged concentric shells are kept as shown in the diagram. Charges on individual shells are as shown. Find the final potential on each shell :



(1) $V_A = \frac{KQ_1}{a} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_B = \frac{K(Q_1 + Q_2 + Q_3)}{c}$

$V_C = \frac{KQ_1}{b} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

(2) $V_A = \frac{KQ_1}{b} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_B = \frac{KQ_1}{a} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_C = \frac{K(Q_1 + Q_2 + Q_3)}{c}$

(3) $V_A = \frac{K(Q_1 + Q_2 + Q_3)}{c}$

$V_B = \frac{KQ_1}{b} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_C = \frac{KQ_1}{a} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

(4) $V_A = \frac{KQ_1}{a} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_B = \frac{KQ_1}{b} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_C = \frac{K(Q_1 + Q_2 + Q_3)}{c}$

Ans. **(4)**

Sol. $V_A = \frac{KQ_1}{a} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_B = \frac{KQ_1}{b} + \frac{KQ_2}{b} + \frac{KQ_3}{c}$

$V_C = \frac{KQ_1}{c} + \frac{KQ_2}{c} + \frac{KQ_3}{c}$

$= \frac{K(Q_1 + Q_2 + Q_3)}{c}$

19. An ideal gas in a closed rigid container is at 50°C and pressure 3.23 kPa. If temperature is doubled, find new pressure in Pa :

(1) 3730 Pa (2) 3230 Pa

(3) 6460 Pa (4) 6430 Pa

Ans. **(1)**

Sol. Closed rigid container

V = constant

$P \propto T$

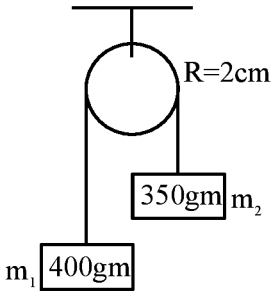
$T_i = 50°\ C = 323\ K$

$T_f = 2 \times 50°C = 100°C = 373\ K$

$\frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{3.23}{P_2} = \frac{323}{373}$

$\therefore\ P_2 = 3730\ Pa$

20. After release, the blocks moves 81 cm in 9 seconds. Find moment of inertia of the pulley :



(1) 97×10^{-4} Kg-m^2 (2) 100×10^{-4} Kg-m^2

(3) 21×10^{-4} Kg-m^2 (4) 87×10^{-4} Kg-m^2

Ans. **(1)**

Sol. $a = \frac{(m_1 - m_2)}{m_1 + m_2 + \frac{I}{R^2}}.g$

$S = ut + \frac{1}{2}at^2$

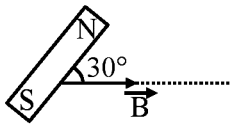
$\frac{81}{100} = \frac{1}{2}\left(\frac{m_1 - m_2}{m_1 + m_2 + \frac{I}{R^2}}\right) g \times (81)$

$500(m_1 - m_2) = (m_1 + m_2) + \frac{I}{R^2}$

$500\left(\frac{50}{1000}\right) = \left(\frac{750}{1000}\right) + \frac{I}{R^2}$

$I = 97 \times 10^{-4}$ Kg-m^2

21. A bar magnet is kept such that it is making an angle of 30° with the magnetic field. The torque acting on the magnet is 0.016 N-m. Find the amount of work done by external agent in rotating the magnet from most stable position to most unstable position.



(1) 0.064 J (2) 0.020 J
(3) 0.034 J (4) 0.055 J

Ans. (1)

Sol. $\tau = \mu B\sin\theta \quad \Rightarrow 0.016 = \mu \times B \times \frac{1}{2}$

$$\Rightarrow \mu = \frac{0.032}{B}$$

$W_{ext} = U_f - U_i = \mu B - (\mu B) = 2\mu B$

$$= 2 \times \frac{0.032}{B} \times B$$

$= 0.064$ J

22. **Statement – I :** Greater is the mass of nucleus, more will be its binding energy.

Statement – II : Nucleus with less $\frac{BE}{A}$ (Binding energy/nucleon) breaks into nucleus with higher $\frac{BE}{A}$.

Choose the correct option :

(1) Statement I is true & statement II is false

(2) Statement I is false & statement II is true

(3) Both are true

(4) Both are false

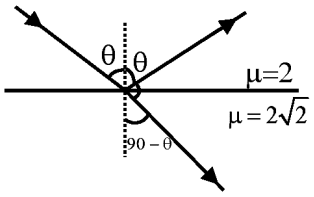
Ans. (3)

Sol. On increasing number of nucleon, BE increase but stability of nucleus depends on BE/A.

23. Light wave are incident from a medium of refractive index 2 making an angle θ with normal on to a medium of refractive index $2\sqrt{3}$. What should be the value of θ for which reflected wave and refracted wave will be perpendicular to each other.

(1) 60° (2) 30°
(3) 53° (4) 45°

Ans. (1)



Sol.

$2\sin\theta = 2\sqrt{3}\sin(90-\theta)$

$\tan\theta = \sqrt{3}$

$\theta = 60°$

24. In a H-like ion, ratio of speed of electron in two orbit is 3 : 2, then ratio of energies in these orbits should be :

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

Ans. (2)

Sol. $v = v.\frac{z}{n}$

$$\frac{v_1}{v_2} = \frac{z_1}{z_2}.\frac{n_2}{n_1} = \frac{3}{2}$$

$$E = -E_0\frac{z^2}{n^2}$$

$$\frac{E_1}{E_2} = \frac{\left(\frac{z_1}{n_1}\right)^2}{\left(\frac{z_2}{n_2}\right)^2} = \frac{9}{4}$$

25. There is a compound microscope of lenses having focal lengths 2 cm and 5 cm and tube length 10 cm. Find magnifying power in normal adjustment. If your answer is 5^{α}, find 'α' :

Ans. (2)

Sol. $f_0 = 2$ cm, fe = 5 cm

$\ell = 10$ cm

$$M = \frac{\ell}{f_0}.\frac{D}{f_e} = 25$$

SECTION-A

1. x & y are the number of moles of electrons involved respectively during oxidation of I^- to I_2 & S^{2-} to S by acidified $K_2Cr_2O_7$.

The value of x+y is ?

Ans. **(12)**

Sol. $Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

no. of moles e^- involved = x = 6

$Cr_2O_7^{2-} + 3S^{2-} + 14H^+ \rightarrow +S + 2Cr^{3+} + 7H_2O$

No. of moles e^- involved = y = 6

Sum of x + y = 6 + 6 = 12

2. 4 kg of water is heated from 4°C of 20°C at constant pressure 10^5 Pa so that density changes from 1000 kg/m^3 to 998 kg/m^3. Then find ΔU (in Joules) given C_s of H_2O= 4.2 Joule/gm.K :

(1) 268799.2 Joule (2) 368900 Joule

(3) 168400 Joule (4) 578876.8 Joule

Ans. **(1)**

Sol. $q = mc_s\Delta T$

$q = 4000 \times 4.2\ (20 - 4)$

$q = 268800$

$w = -P_{ext}(V_2 - V_1)$

$$w = -10^5\left(\frac{4}{998} - \frac{4}{1000}\right)$$

w = – 0.8 Joule

$\Delta U = q + w$

ΔU =268800 – 0.8

ΔU = 268799.2 Joule

3. Two solutes, 0.3 gm of A (Mw = 60 gm/mol) & 0.9 gm of B (Mw = 180 gm/mol) are dissolved in 100 ml solution. Find osmotic pressure of solution at 300 K (in atm) (R = 0.082 atm-L/mol-K)

(1) 1.23 (2) 2.46

(3) 4.92 (4) 3.69

Ans. **(2)**

Sol. $\pi = (C_1 + C_2)$

$$= \left(\frac{0.3\times1000}{60\times100} + \frac{0.9\times1000}{180\times100}\right)\times0.082\times300$$

= 2.46 atm

4. For a reaction at 300K, on addition of catalyst, activation energy of reaction lowered by 10 kJ. Then calculate the value of $\log\frac{K_{catalysed}}{K_{uncatalysed}}$

(1) 1.74 (2) 0.174

(3) 17.4 (4) 3.48

Ans. **(1)**

Sol. $$\frac{K_{catalyst}}{K_{uncatalyst}} = e^{\frac{\Delta E_a}{RT}}$$

$$\ln\frac{K_{catalyst}}{K_{uncatalyst}} = \frac{\Delta E_a}{RT}$$

$$\log\frac{K_{catalyst}}{K_{uncatalyst}} = \frac{\Delta E_a}{2.303RT}$$

$$= \frac{10\times1000}{2.303\times8.314\times300}$$

$$\log\frac{K_{catalyst}}{K_{uncatalyst}} = 1.74$$

5. Line corresponding to lyman series are L_1, L_2, L_3, L_4….., among these L_1 line corresponds to lowest energy. Similarly lines corresponding to balmer series are B_1, B_2, B_3, B_4……, among these B_1 line corresponds to lowest energy

ΔE_L = Energy of 1st line of lyman series

ΔE_B = Energy of 1st line of balmer series

If $\Delta E_L = x.\Delta E_B$

Calculate $(x \times 10^{-1})$

Ans. **(54)**

Sol. $$\Delta E_L = 13.6\times Z^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 13.6Z^2\times\frac{3}{4}$$

$$\Delta E_B = 13.6\times Z^2\times\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 13.6\times Z^2\times\frac{5}{4\times9}$$

$$\frac{\Delta E_L}{\Delta E_B} = \frac{3}{5}\times9 = \frac{27}{5} = x$$

$$= \left(\frac{27}{5}\times10\right)\times10^{-1}$$

6.

List-I (Isothermal Process)		List-I (work done) ($V_f > V_i$)	
P.	Reversible expansion	1.	$w = 0$
Q.	Free expansion	2.	$w = -nRT \ln\frac{V_f}{V_i}$
R.	Irreversible expansion	3.	$w = -P_{ext}(V_f - V_i)$
S.	Irreversible Compression	4.	$w = -P_{ext}(V_i - V_f)$

Select the correct match

	P	Q	R	S
(A)	4	3	2	1
(B)	2	1	3	4
(C)	1	2	3	4
(D)	3	4	1	2

Ans. (2)

Sol. Theoritical

7. Electrolysis of aqueous solution of $CuSO_4$ is carried out, where 300 mg of copper is deposited (atomic mass of Cu = 63.54). After this 600 milli amp. current is further passed for 28 minutes. Calculate total volume of O_2 released (in ml).

(Given 1 mole of gas occupy 22.4 litre)

(Given $Cu^{+2}(aq) + 2e^- \longrightarrow Cu(s)$

$2H_2O(l) \longrightarrow O_2(g) + 4H^+(aq) + 4e^-$

Ans. (111)

Sol. Eq of Cu = Eq of O_2

$$\frac{300\times10^{-3}\times2}{63.54} = n_{O_2}\times4$$

$$2.36 \times 10^{-3} = n_{O_2}$$

When current is further passed

$$n_{O_2}\times4 = \frac{600\times28\times60}{96500\times1000}$$

$$n_{O_2} = 2.611 \times 10^{-3}$$

Total O_2 released

$= [10^{-3} \times (2.36 + 2.611)] \times 22400$ ml

$= 111.35$ ml

8. W gm of non-volatile electrolyte solute is added in 100 ml pure water (P° = 640 mm Hg) showing vapour pressure of solution 600 mm Hg.

This solution have b.p. of 375 K.

Given K_b of $H_2O = 0.52 \ \frac{K-kg}{mol}$,

Molar mass of solute = M

Select the correct option about mole fraction of solute (X_{solute}).

(1) $\frac{1.3}{8}\left(\frac{W}{M}\right)$ (2) $\frac{8}{1.3}\left(\frac{W}{M}\right)$

(3) $\frac{2.6}{16}\left(\frac{M}{W}\right)$ (4) $\frac{1.3}{8}\left(\frac{M}{W}\right)$

Ans. (1)

Sol. $\Delta T_b = i \times K_b \times m$

$$2 = i\times0.52\times\frac{\frac{W}{M}}{\frac{100}{1000}}$$

$$i\times\frac{W}{M} = 2\times\frac{100}{1000}\times\frac{1}{.52}$$

$$i = \frac{1}{2.6}\times\frac{M}{W}$$

$$RLVP = \frac{P^\circ - P_S}{P^\circ} = i\times X_{solute}$$

$$\frac{640-600}{640} = i\times X_{solute}$$

$$\frac{1}{16} = \frac{1}{2.6}\times\frac{M}{W}\times X_{solute}$$

$$X_{solute} = \frac{1.3}{8}\times\frac{W}{M}$$

9. For a chemical reaction :

$A \rightarrow D$

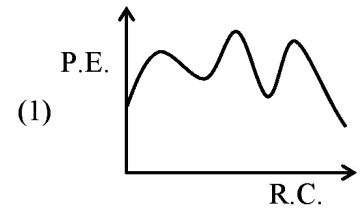
Mechanism is

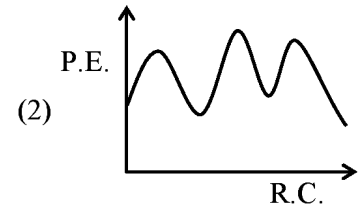
Step-1 : $A \rightarrow B$: ΔH = +ve

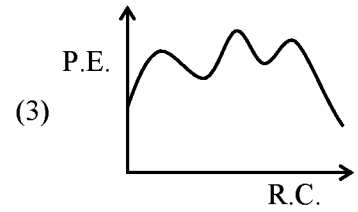
Step-2 : $B \rightarrow C$: ΔH = –ve

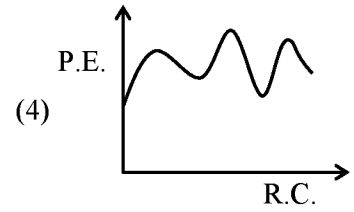
Step-3 : $C \rightarrow D$: ΔH = –ve

Select the correct energy plot

(1) 

(2) 

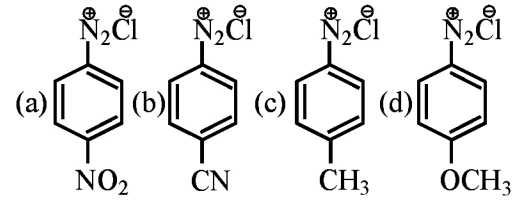
(3) 

(4) 

Ans. (1)

Sol. $\Delta H = E_{Product} - E_{Reactant}$

10. Correct order of stability is :



(1) a > b > c > d (2) d > c > b > a

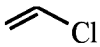
(3) b > a > c > d (4) d > b > c > a

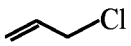
Ans. (2)

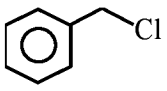
Sol. +M group or +I group increases stability (i.e. $-OCH_3$–CH3)

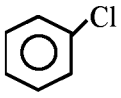
–M decreases stability (i.e. $-NO_2$ and –CN)

11. Match the List-I and List-II

(1)  (I) Vinyl chloride

(2)  (II) Allyl chloride

(3)  (III) Aryl chloride

(4)  (IV) Benzyl chloride

(1) A → I, B → II, C → III, D → IV

(2) A → I, B → II, C → IV, D → III

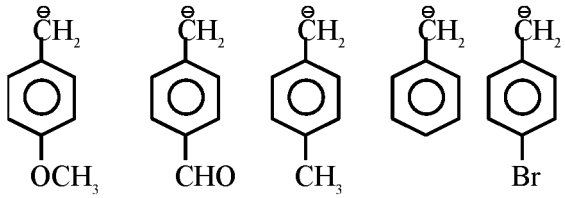
(3) A → III, B → II, C → I, D → IV

(4) A → III, B → II, C → IV, D → II

Ans. (2)

Sol. Common Names

12. The correct order of stability of given carbanions is



(1) a > b > c > d > e

(2) b > e > d > a > c

(3) a > c > d > e > b

(4) b > e > d > c > a

Ans. (4)

Sol. Electron withdrawing group increase the stability of carbanions.

13. 0.5 gm of unknown organic compound undergo Duma's method for estimation of nitrogen. Percentage of nitrogen gas collected over water at P = 715 mm and 27°C has volume = 70 ml. Calculate % N in the unknown organic compound. (aq. Tension = 15 mm)

Ans. (14.65)

Sol. $P_{N_2} = (715-15)\text{mm} = \frac{700}{760}\text{atm}$

$$V_{N_2} = 70\,\text{ml} = \frac{70}{1000}\text{l}$$

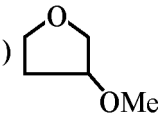
$$n_{N_2} = \frac{PV}{RT} = \frac{\left(\frac{700}{700}\right)\times\left(\frac{70}{1000}\right)}{0.821\times 300}$$

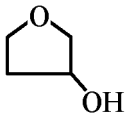
$$W_{N_2} = \frac{700}{700}\times\frac{\frac{70}{1000}}{0.821\times 300}\times 28$$

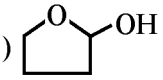
$$\%\,N = \frac{W_{N_2}}{0.5}\times 100 = \frac{700}{760}\times\frac{\frac{70/1000}{0.821\times 300}\times 28}{0.5}\times 100$$

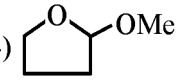
$= 14.65\%$

14. Which of the following gives positive tollen's test ?

(1) 

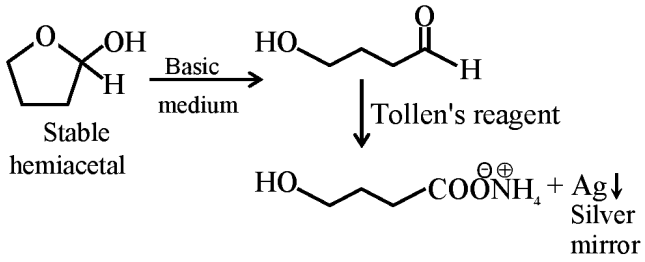
(2) 

(3) 

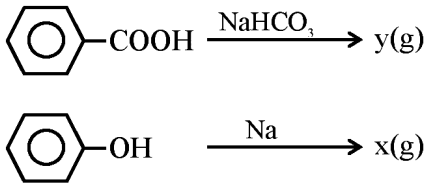
(4) 

Ans. (3)

Sol. In basic medium cyclic hemiacetal isomers to open hydroxyl aldehyde compound which easily gives positive tollen's test.



15.



Sum of molar mass of gas (x) & (y) is

(1) 44 (2) 88

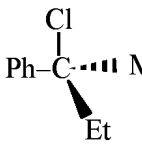
(3) 46 (4) 160

Ans. (3)

Sol. x = H_2 (gas), y = CO_2 (gas)

Sum of molar mass = 2 + 44 = 46

16. **Statement-1 :** CH_2=CH–Cl is having stronger C–Cl bond then CH_2–CH_2–Cl.

Statement-2 :  Me will rotate the plane polarised light after solvation.

(1) Both statements-I and II are correct

(2) Both statements-I and II are incorrect

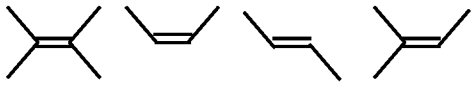
(3) Statement-I is correct and statement-II is incorrect

(4) Statement-I is incorrect and statement-II is correct.

Ans. (1)

Sol. Theory based

17. Correct stability order of alkene ::



(A) (B) (C) (D)

(1) A > D > C > B (2) D > A > B > C

(3) A > D > B > C (4) B > C > D A

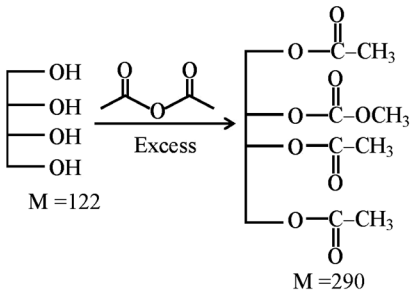
Ans. (1)

Sol. Hyperconjugation (+H) and inductive group (+I) increases the stability of alkenes.

18. Hydroxy compound (A) with molecular mass = 122 react with excess of acetic anhydride and gives compound (X) with molecular mass = 290, then find the no. of hydroxy groups in given compound (A).

Ans. (42)

Sol.



No. of OH groups = $\frac{290-122}{4} = 42$

19. **Statement-I** Among V_2O_5, $[TiF_6]^{3-}$, $[Fe(CN)_6]^{3-}$, $[CoF_6]^{3-}$ paramagnetic species are three in number.

Statement-II . Increasing number of unpaired electrons in the following.

$[Fe(CN)_6]^{4-} < [Fe(CN)_6]^{3-} < [Fe(H_2O)_6]^{2+}$

(1) Both statements are correct

(2) Statement-I is correct ; statement-II is incorrect

(3) Statement-I is incorrect statement-II is correct

(4) Both statements are incorrect

Ans. (1)

Sol. $[TiF_6]^{3-} \rightarrow$ 1 unpaired electron

$[Fe(CN)_6]^{3-} \rightarrow$ 1 unpaired electron

$[CoF_6]^{3-} \rightarrow$ 4 unpaired electron

$[Fe(H_2O)_6]^{2+} \rightarrow$ 4 unpaired electron

$[Fe(CN)_6]^{3-} \rightarrow$ 1 unpaired electron

$[Fe(CN)_6]^{4-} \rightarrow$ 0 unpaired electron

20.

	List-I Species	List-II Hybridization	List-III Shape
(A)	IF_3	sp^3	T-shape
(B)	IF_7	sp^3d^3	P.B.P
(C)	IF_5	sp^3d^2	square pyramidal
(D)	ClO_4^-	sp^2d	square planar

Select the correct match

(1) A, B, C (2) A, B, C, D

(3) B, C, D (4) A, B, D

Ans. **(1)**

Sol. $ClO_4^- \rightarrow sp^3 \rightarrow$ tetrahedral, so (D) is incorrect, all others are correct.

21. **Statement-I** $[Co(CO_3)_3]^{3-}$ has magnetic moment of 4.9 BM & hybridization is sp^3d^2

Statement-II $[Ni(CN)_4]^{2-}$, $[Cr(H_2O)_6]^{2+}$ and $[MnF_6]^{4-}$ have square planar, octahedral and octahedral geometry respectively and dsp^2, sp^3d^2, d^2sp^3 hybridization respectively and $\mu = 0$, 4.9 BM, 5.9 BM respectively.

(1) Both statements are correct

(2) Statement-I is correct & statement-II is incorrect

(3) Statement-I is incorrect & statement-II is correct

(4) Both statements are incorrect.

Ans. **(4)**

Sol. $[Co(CO_3)_3]^{3-}$ is d^2sp^3 hybridized

$[MnF_6]^{4-}$ is sp^3d^2 hybridized.

22. Select correct statements(s)

(A) NF_3 has more dipole moment than NH_3

(B) O_2^{2-} and F_2 both have same bond order

(C) In O_3 central oxygen atom has –1 formal charge

(D) In NO_2 all the atoms follow octet rule, so it is stable.

(E) BeH_2 is planar

(1) B, C (2) A, B, C (3) C, D, E (4) B, E

Ans. **(4)**

Sol. (1) dipole moment $NF_3 < NH_3$

(2) O_2^{2-}, F_2 both have B.O = 1

(3) In O_3 central oxygen atom has +1 formal charge

(4) In NO_2, octet of 'N' atom is not complete

(5) BeH_2 is linear, so planar

23. Salt (X) is soluble in water.

Salt (Y) is sparingly soluble in water.

Salt (Z) is soluble only in hot water.

X, Y, Z respectively are.

(1) AgCl, Hg_2Cl_2, $PbCl_2$

(2) $AlCl_3$, AgCl, $PbCl_2$

(3) $BaCl_2$, $PbCl_2$, Hg_2Cl_2

(4) $MgCl_2$, Hg_2Cl_2, $CaCl_2$

Ans. **(2)**

Sol. Theory based.

24. Select correct statements.

(I) Hybridisation of ClO_4^- is dsp^2

(II) $[Ni(CN)_4]^{2-}$ is tetrahedral

(III) $[Co(H_2O)_6]^{2+}$ has sp^3d^2 hybridisation

(IV) $[Mn(CN)_6]^{4-}$ has sp^3d^2 hybridisation

(1) II and III and (2) III only

(3) II, III and IV only (4) I, II, III and IV

Ans. **(2)**

Sol. (I) $ClO_4^- \rightarrow sp^3$

(II) $Ni^{2+} \rightarrow 3d^8 \rightarrow dsp^2$ (square planar)

(III) $Co^{2+} \rightarrow 3d^7 \rightarrow t_{2g}^{2,2,1}eg^{1,1} \rightarrow sp^3d^2$

(IV) $Mn^{2+}3d^5 \rightarrow t_{2g}^{2,2,1}eg^{0,0} \rightarrow d^2sp^3$

25. **Statement-I** : K > Mg > Al > B metallic character order.

Statement-II : Ionic radius of any element is less than its atomic radius.

In the light of above statements, choose the most appropriate answer from the options given below :

(1) Both statements are true

(2) Statement I is false but statement II is true.

(3) Both statements are False.

(4) Statement I is true but statement II is false.

Ans. **(4)**

Sol. Statement-I : Correct

EN ↑ metallic character ↓

Metallic character : K > Mg > Al > B

EN : 0.8 < 1.2 < 1.5 < 2.0

Statement-II : Incorrect

Ionic size $M^+ < M < M^-$

Anionic radius > Atomic radius.