Test Booklet Code

G

Aakash

Medical | IIT-JEE | Foundations

(Divisions of Aakash Educational Services Ltd.)

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Time : 3 hrs. **M.M. : 360**

Answers & Solutions

for

JEE (MAIN)-2014

(Mathematics, Physics & Chemistry)

Important Instructions :

1. The test is of **3 hours** duration.
2. The Test Booklet consists of **90** questions**.** The maximum marks are **360.**
3. There are ***three*** parts in the question paper A, B, C consisting of **Mathematics**, **Physics** and **Chemistry** having 30 questions in each part of equal weightage. Each question is allotted 4 **(four)** marks for each correct response.
4. *Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question. ¼ (one-fourth) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.*
5. There is only one correct response for each question. Filling up more than one response in each question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instruction 4 above.
6. Use ***Blue/Black Ball Point Pen only*** for writing particulars/marking responses on ***Side-1*** and ***Side-2*** of the Answer Sheet. ***Use of pencil is strictly prohibited.***
7. No candidate is allowed to carry any textual material, printed or written, bits of papers, pager, mobile phone, any electronic device, etc. except the Admit Card inside the examination hall/room.
8. The **CODE** for this Booklet is **G.** Make sure that the **CODE** printed on Side-2 of the Answer Sheet is the same as that on this booklet. In case of discrepancy, the candidate should immediately report the matter to the Invigilator for replacement of both the Test Booklet and the Answer Sheet.

PART–A : MATHEMATICS

1. If $x = -1$ and $x = 2$ are extreme points of $f(x) = \alpha \log|x| + \beta x^2 + x$ then

(1) $\alpha = -6,\ \beta = -\frac{1}{2}$ (2) $\alpha = 2,\ \beta = -\frac{1}{2}$

(3) $\alpha = 2,\ \beta = \frac{1}{2}$ (4) $\alpha = -6,\ \beta = \frac{1}{2}$

Answer (2)

Sol. $f(x) = \alpha \log|x| + \beta x^2 + x$

$f'(x) = \frac{\alpha}{x} + 2\beta x + 1 = 0$ at $x = -1, 2$

$-\alpha - 2\beta + 1 = 0 \Rightarrow \alpha + 2\beta = 1$ ...(i)

$\frac{\alpha}{2} + 4\beta + 1 = 0 \Rightarrow \alpha + 8\beta = -2$ ...(ii)

$6\beta = -3 \Rightarrow \beta = -\frac{1}{2}$

$\therefore\ \alpha = 2$

2. The locus of the foot of perpendicular drawn from the centre of the ellipse $x^2 + 3y^2 = 6$ on any tangent to it is

(1) $(x^2 - y^2)^2 = 6x^2 - 2y^2$

(2) $(x^2 + y^2)^2 = 6x^2 + 2y^2$

(3) $(x^2 + y^2)^2 = 6x^2 - 2y^2$

(4) $(x^2 - y^2)^2 = 6x^2 + 2y^2$

Answer (2)

Sol. Here ellipse is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, where $a^2 = 6$, $b^2 = 2$

Now, equation of any variable tangent is

$y = mx \pm \sqrt{a^2m^2 + b^2}$ ...(i)

where m is slope of the tangent

So, equation of perpendicular line drawn from centre to tangent is

$y = \frac{-x}{m}$ ...(ii)

Eliminating m, we get

$(x^2 + y^2)^2 = a^2x^2 + b^2y^2$

$\Rightarrow$ $\boxed{(x^2 + y^2)^2 = 6x^2 + 2y^2}$

3. Let $f_k(x) = \frac{1}{k}(\sin^k x + \cos^k x)$ where $x \in R$ and $k \geq 1$. Then $f_4(x) - f_6(x)$ equals

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

(3) $\frac{1}{12}$ (4) $\frac{1}{6}$

Answer (3)

Sol. $f_k(x) = \frac{1}{k}(\sin^k x + \cos^k x)$

$f_4(x) - f_6(x) = \frac{1}{4}(\sin^4 x + \cos^4 x) - \frac{1}{6}(\sin^6 x + \cos^6 x)$

$= \frac{1}{4}[1 - 2\sin^2 x \cos^2 x] - \frac{1}{6}[1 - 3\sin^2 x \cos^2 x]$

$= \frac{1}{4} - \frac{1}{6} = \frac{1}{12}$

4. If $X = \{4^n - 3n - 1 : n \in N\}$ and $Y = \{9(n - 1) : n \in N\}$, where N is the set of natural numbers, then $X \cup Y$ is equal to

(1) $Y - X$ (2) X

(3) Y (4) N

Answer (3)

Sol. $X = \{(1+3)^n - 3n - 1, n \in N\}$

$= 3^2 ({}^nC_2 \quad {}^nC_3.3 \ \ldots \ 3^{n\ 2}), n \quad N\}$

= {Divisible by 9}

$Y = \{9(n - 1), n \in N\}$

= (All multiples of 9}

So, $X \subseteq Y$

i.e., $\boxed{X \cup Y = Y}$

5. If A is an 3×3 non-singular matrix such that $AA' = A'A$ and $B = A^{-1}A'$, then BB' equals

(1) I (2) B^{-1}

(3) $(B^{-1})'$ (4) $I + B$

Answer (1)

Sol. $BB' = (A^{-1}.A')(A(A^{-1})')$

$= A^{-1}.A.A'.(A^{-1})^1$ {as $AA' = A'A$}

$= I(A^{-1}A)'$

$= I.I = I^2 = I$

6. The integral $\int\left(1+x-\frac{1}{x}\right)e^{x+\frac{1}{x}}dx$ is equal to

(1) $xe^{x+\frac{1}{x}}+c$ (2) $(x+1)e^{x+\frac{1}{x}}+c$

(3) $-xe^{x+\frac{1}{x}}+c$ (4) $(x-1)e^{x+\frac{1}{x}}+c$

Answer (1)

Sol. $I = \int\left\{e^{\left(x+\frac{1}{x}\right)}+x\left(1-\frac{1}{x^2}\right)e^{x+\frac{1}{x}}\right\}dx$

$= x.e^{x \quad \frac{1}{x}} \quad c$

As $\quad (xf'(x) \quad f(x))dx \quad xf(x) \quad c$

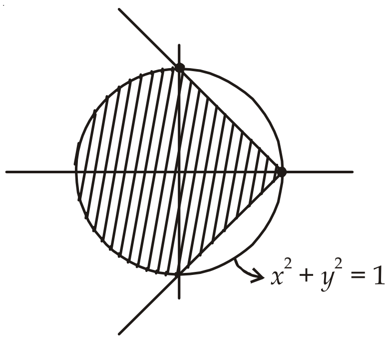
7. The area of the region described by $A = \{(x, y) : x^2 + y^2 \leq 1 \text{ and } y^2 \leq 1 - x\}$ is

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

(3) $\frac{\pi}{2}+\frac{2}{3}$ (4) $\frac{\pi}{2}+\frac{4}{3}$

Answer (4)

Sol.



Shaded area

$\frac{(1)^2}{2} \quad 2 \int_0^1 \sqrt{(1 \quad x)}\,dx$

$\frac{}{2} \quad \frac{2(1 \quad x)^{3/2}}{3/2}(\quad 1)\Big|_0^1$

$\frac{}{2} \quad \frac{4}{3}(0 \quad (\quad 1))$

$\frac{}{2} \quad \frac{4}{3}$

8. The image of the line

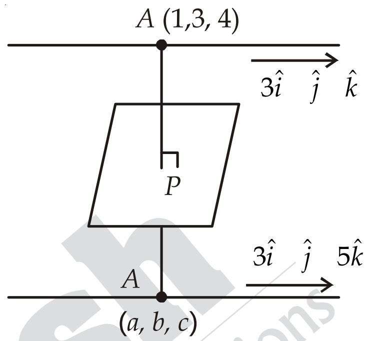
$\frac{x-1}{3}=\frac{y-3}{1}=\frac{z-4}{-5}$ in the plane $2x - y + z + 3 = 0$ is the line

(1) $\frac{x+3}{-3}=\frac{y-5}{-1}=\frac{z+2}{5}$ (2) $\frac{x-3}{3}=\frac{y+5}{1}=\frac{z-2}{-5}$

(3) $\frac{x-3}{-3}=\frac{y+5}{-1}=\frac{z-2}{5}$ (4) $\frac{x+3}{3}=\frac{y-5}{1}=\frac{z-2}{-5}$

Answer (4)

Sol.



$\frac{a \quad 1}{2} \quad \frac{b \quad 3}{1} \quad \frac{c \quad 4}{1}$

$\Rightarrow$ $a = 2\lambda + 1$

$b = 3 - \lambda$

$c = 4 + \lambda$

$P \qquad 1, 3 \quad \frac{}{2}, 4 \quad \frac{}{2}$

$2(\quad 1) \quad 3 \quad \frac{}{2} \qquad 4 \quad \frac{}{2} \quad 3 \quad 0$

$2 \quad 2 \quad 3+\frac{}{2} \quad 4 \quad \frac{}{2} \quad 3 \quad 0$

$3\lambda + 6 = 0 \Rightarrow \lambda = -2$

$a = -3, b = 5, c = 2$

So the equation of the required line is

$\frac{x \quad 3}{3} \quad \frac{y \quad 5}{1} \quad \frac{z \quad 2}{5}$

9. The variance of first 50 even natural numbers is

(1) 833 (2) 437

(3) $\frac{437}{4}$ (4) $\frac{833}{4}$

Answer (1)

Sol. Variance $= \dfrac{\Sigma x_i^2}{N} - (\bar{x})^2$

$$\Rightarrow \quad \sigma^2 = \frac{2^2+4^2+...+100^2}{50} - \left(\frac{2+4+...+100}{50}\right)^2$$

$$= \frac{4(1^2+2^2+3^2+....+50^2)}{50} - (51)^2$$

$$= 4\left(\frac{50\times 51\times 101}{50\times 6}\right) - (51)^2$$

$= 3434 - 2601$

$\Rightarrow \quad \sigma^2 = 833$

10. If z is a complex number such that $|z| \geq 2$, then the minimum value of $\left|z+\frac{1}{2}\right|$

(1) Lies in the interval (1, 2)

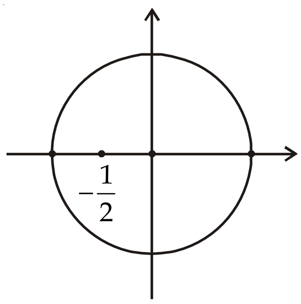
(2) Is strictly greater than $\frac{5}{2}$

(3) Is strictly greater than $\frac{3}{2}$ but less than $\frac{5}{2}$

(4) Is equal to $\frac{5}{2}$

Answer (1)

Sol.



$\left|z+\frac{1}{2}\right|$

So, $\left||z|-\frac{1}{2}\right| \leq \left|z+\frac{1}{2}\right|$

$\Rightarrow \quad \left|z+\frac{1}{2}\right| \geq \left|2-\frac{1}{2}\right|$

$\Rightarrow \quad \left|z+\frac{1}{2}\right| \geq \frac{3}{2}$

11. Three positive numbers form an increasing G.P. If the middle term in this G.P. is doubled, the new numbers are in A.P. Then the common ratio of the G.P. is

(1) $3+\sqrt{2}$ (2) $2-\sqrt{3}$

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

Answer (3)

Sol. $a, ar, ar^2 \rightarrow$ G.P.

$a, 2ar, ar^2 \rightarrow$ A.P.

$2 \times 2ar = a + ar^2$

$4r = 1 + r^2$

$\Rightarrow \quad r^2 - 4r + 1 = 0$

$$r = \frac{4 \pm \sqrt{16-4}}{2} = 2 \pm \sqrt{3}$$

$\boxed{r = 2+\sqrt{3}}$

$r = 2-\sqrt{3}$ is rejected

$\because \quad (r > 1)$

G.P. is increasing.

12. If the coefficients of x^3 and x^4 in the expansion of $(1 + ax + bx^2)(1 - 2x)^{18}$ in powers of x are both zero, then (a, b) is equal to

(1) $\left(14, \frac{251}{3}\right)$ (2) $\left(14, \frac{272}{3}\right)$

(3) $\left(16, \frac{272}{3}\right)$ (4) $\left(16, \frac{251}{3}\right)$

Answer (3)

Sol. $(1 + ax + bx^2)(1 - 2x)^{18}$

$(1 + ax + bx^2)[{}^{18}C_0 - {}^{18}C_1(2x) + {}^{18}C_2(2x)^2 - {}^{18}C_3(2x)^3 + {}^{18}C_4(2x)^4 - ....]$

Coeff. of $x^3 = -{}^{18}C_3.8 + a \times 4.{}^{18}C_2 - 2b \times 18 = 0$

$$= -\frac{18\times 17\times 16}{6}.8 + \frac{4a+18\times 17}{2} - 36b = 0$$

$= -51 \times 16 \times 8 + a \times 36 \times 17 - 36b = 0$

$= -34 \times 16 + 51a - 3b = 0$

$= 51a - 3b = 34 \times 16 = 544$

$= 51a - 3b = 544$ ... (i)

Only option number (3) satisfies the equation number (i).

13. Let a, b, c and d be non-zero numbers. If the point of intersection of the lines $4ax + 2ay + c = 0$ and $5bx + 2by + d = 0$ lies in the fourth quadrant and is equidistant from the two axes then

(1) $2bc + 3ad = 0$ (2) $3bc - 2ad = 0$

(3) $3bc + 2ad = 0$ (4) $2bc - 3ad = 0$

Answer (2)

Sol. Let $(\alpha, -\alpha)$ be the point of intersection

$\therefore \quad 4a\alpha - 2a\alpha + c = 0 \qquad \dfrac{c}{2a}$

and $5b\alpha - 2b\alpha + d = 0 \qquad \dfrac{d}{3b}$

$3bc = 2ad$

$3bc - 2ad = 0$

Alternative method :

The point of intersection will be

$$\frac{x}{2ad-2bc} = \frac{-y}{4ad-5bc} = \frac{1}{8ab-10ab}$$

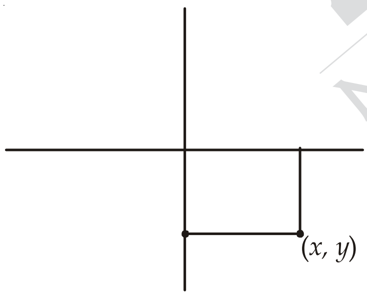
$$\Rightarrow \quad x = \frac{2(ad-bc)}{-2ab}$$

$$\Rightarrow \quad y = \frac{5bc-4ad}{-2ab}$$

$\because$ Point of intersection is in fourth quadrant so x is positive and y is negative.

Also distance from axes is same

So $x = -y$ ($\because$ distance from x-axis is $-y$ as y is negative)



$$\frac{2(ad-bc)}{-2ab} = \frac{-(5bc-4ad)}{-2ab}$$

$2ad - 2bc = -5bc + 4ad$

$\Rightarrow \quad 3bc - 2ad = 0 \qquad$ ...(i)

14. If $\left[\vec{a}\times\vec{b}\ \ \vec{b}\times\vec{c}\ \ \vec{c}\times\vec{a}\right] = \lambda[\vec{a}\ \vec{b}\ \vec{c}]^2$ then λ is equal to

(1) 3 (2) 0

(3) 1 (4) 2

Answer (3)

Sol. L.H.S.

$= (\vec{a}\times\vec{b})\cdot[(\vec{b}\times\vec{c})\times(\vec{c}\times\vec{a})]$

$= (\vec{a}\times\vec{b})\cdot[(\vec{b}\times\vec{c}\cdot\vec{a})\vec{c} - (\vec{b}\times\vec{c}\cdot\vec{c})\vec{a}]$

$= (\vec{a}\times\vec{b})\cdot[[\vec{b}\ \vec{c}\ \vec{a}]\vec{c}] \qquad [\because \vec{b}\times\vec{c}.\vec{c} = 0]$

$= [\vec{a}\ \vec{b}\ \vec{c}]\cdot(\vec{a}\times\vec{b}\cdot\vec{c}) = [\vec{a}\ \vec{b}\ \vec{c}]^2$

$[\vec{a}\times\vec{b}\ \ \vec{b}\times\vec{c}\ \ \vec{c}\times\vec{a}] = [\vec{a}\ \vec{b}\ \vec{c}]^2$

So $\lambda = 1$

15. Let A and B be two events such that $P(\overline{A\cup B}) = \frac{1}{6}$, $P(A\cap B) = \frac{1}{4}$ and $P(\overline{A}) = \frac{1}{4}$, where $\overline{A}$ stands for the complement of the event A. Then the events A and B are

(1) Equally likely but not independent

(2) Independent but not equally likely

(3) Independent and equally likely

(4) Mutually exclusive and independent

Answer (2)

Sol. $P(\overline{A\cup B}) = \dfrac{1}{6} \Rightarrow P(A\cup B) = 1 - \dfrac{1}{6} = \dfrac{5}{6}$

$P(\overline{A}) = \dfrac{1}{4} \Rightarrow P(A) = 1 - \dfrac{1}{4} = \dfrac{3}{4}$

$\because \quad P(A\cup B) = P(A) + P(B) - P(A\cap B)$

$\dfrac{5}{6} = \dfrac{3}{4} + P(B) - \dfrac{1}{4}$

$P(B) = \dfrac{1}{3}$

$\because \quad P(A) \neq P(B)$ so they are not equally likely.

Also $P(A) \times P(B) = \dfrac{3}{4}\times\dfrac{1}{3} = \dfrac{1}{4}$

$= P(A \cap B)$

$\because \quad P(A\cap B) = P(A)\cdot P(B)$ so A & B are independent.

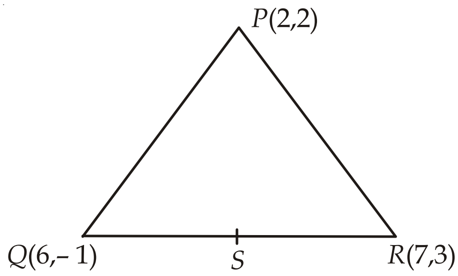
16. Let PS be the median of the triangle with vertices $P(2, 2)$, $Q(6, -1)$ and $R(7, 3)$. The equation of the line passing through $(1, -1)$ and parallel to PS is

(1) $2x + 9y + 7 = 0$ (2) $4x + 7y + 3 = 0$

(3) $2x - 9y - 11 = 0$ (4) $4x - 7y - 11 = 0$

Answer (1)

Sol.



S is mid-point of QR

So $S = \left(\frac{7+6}{2}, \frac{3-1}{2}\right)$

$= \left(\frac{13}{2}, 1\right)$

Slope of $PS = \frac{2-1}{2-\frac{13}{2}} = -\frac{2}{9}$

Equation of line $\Rightarrow y-(-1) = -\frac{2}{9}(x-1)$

$9y + 9 = -2x + 2 \Rightarrow 2x + 9y + 7 = 0$

17. $\lim\limits_{x\to 0} \frac{\sin(\pi\cos^2 x)}{x^2}$ is equal to

(1) 1 (2) $-\pi$

(3) π (4) $\frac{\pi}{2}$

Answer (3)

Sol. $\lim\limits_{x\to 0} \frac{\sin(\pi\cos^2 x)}{x^2}$

$= \lim\limits_{x\to 0} \frac{\sin(\pi(1-\sin^2 x)}{x^2}$

$= \lim\limits_{x\to 0} \sin\frac{(\pi-\pi\sin^2 x)}{x^2}$

$= \lim\limits_{x\to 0} \sin\frac{(\pi\sin^2 x)}{x^2}$ $[\because \sin(\pi-\theta) = \sin\theta]$

$= \lim\limits_{x\to 0} \sin\frac{(\pi\sin^2 x)}{(\pi\sin^2 x)} \times \frac{\pi\sin^2 x}{x^2}$

$= \lim\limits_{x\to 0} 1\times\pi\left(\frac{\sin x}{x}\right)^2 = \pi$

18. Let α and β be the roots of equation $px^2 + qx + r = 0$, $p \neq 0$. If p, q, r are in A.P. and $\frac{1}{\alpha}+\frac{1}{\beta} = 4$, then the value of $|\alpha - \beta|$ is

(1) $\frac{2\sqrt{17}}{9}$ (2) $\frac{\sqrt{34}}{9}$

(3) $\frac{2\sqrt{13}}{9}$ (4) $\frac{\sqrt{61}}{9}$

Answer (3)

Sol.

$\because$ p, q, r are in AP

$2q = p + r$ ...(i)

Also $\frac{1}{\alpha}+\frac{1}{\beta} = 4$

$\Rightarrow \frac{\alpha+\beta}{\alpha\beta} = 4$

$= \frac{-\frac{q}{p}}{\frac{r}{p}} = 4 \Rightarrow q = -4r$ ...(ii)

From (i)

$2(-4r) = p + r$

$p = -9r$

$q = -4r$

$r = r$

Now $|\alpha-\beta| = \sqrt{(\alpha+\beta)^2 - 4\alpha\beta}$

$= \sqrt{\left(\frac{-q}{p}\right)^2 - \frac{4r}{p}}$

$= \frac{\sqrt{q^2-4pr}}{|p|}$

$= \frac{\sqrt{16r^2+36r^2}}{|-9r|}$

$= \frac{2\sqrt{13}}{9}$

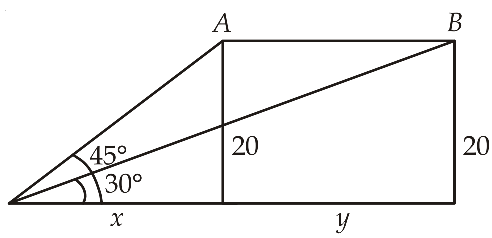
19. A bird is sitting on the top of a vertical pole 20 m high and its elevation from a point O on the ground is 45°. It flies off horizontally straight away from the point O. After one second, the elevation of the bird from O is reduced to 30°. Then the speed (in m/s) of the bird is

(1) $40\left(\sqrt{3}-\sqrt{2}\right)$ (2) $20\sqrt{2}$

(3) $20\left(\sqrt{3}-1\right)$ (4) $40\left(\sqrt{2}-1\right)$

Answer (3)

Sol.



$t = 1$ s

From figure $\tan 45° = \dfrac{20}{x}$

and $\tan 30° = \dfrac{20}{x+y}$

so, $y = 20(\sqrt{3}-1)$

i.e., speed = $20(\sqrt{3}-1)$ m/s.

20. If $a \in R$ and the equation

$-3(x - [x])^2 + 2(x - [x]) + a^2 = 0$

(where $[x]$ denotes the greatest integer $\le x$) has no integral solution, then all possible values of a lie in the interval

(1) (1, 2) (2) (–2, –1)

(3) $(-\infty, -2) \cup (2, \infty)$ (4) $(-1, 0) \cup (0, 1)$

Answer (4)

Sol. $-3(x - [x])^2 + 2[x - [x]) + a^2 = 0$

$3\{x\}^2 - 2\{x\} - a^2 = 0$

$a \ne 0,\ 3\left(\{x\}^2 - \dfrac{2}{3}\{x\}\right) = a^2$

$a^2 = 3\left(\{x\} - \dfrac{1}{3}\right)^2 - \dfrac{1}{3}$

$0 \le \{x\} < 1$ and $-\dfrac{1}{3} \le \{x\} - \dfrac{1}{3} < \dfrac{2}{3}$

$0 \quad 3 \quad \{x\} \quad \dfrac{1}{3}^{\ 2} \quad \dfrac{4}{3}$

$\dfrac{1}{3} \quad 3 \quad \{x\} \quad \dfrac{1}{3}^{\ 2} \quad \dfrac{1}{3} \quad 1$

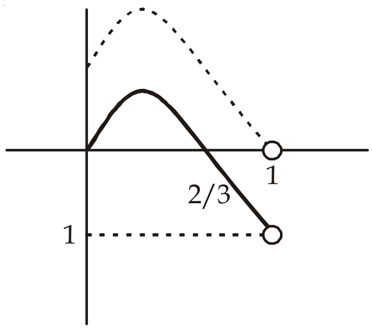
For non-integral solution

$0 < a^2 < 1$ and $a \in (-1, 0) \cup (0, 1)$

Alternative

$-3\{x\}^2 + 2\{x\} + a^2 = 0$

Now, $-3\{x\}^2 + 2\{x\}$



to have no integral roots $0 < a^2 < 1$

$\therefore\ a \in (-1, 0) \cup (0, 1)$

21. The integral

$\displaystyle\int_0^{\pi} \sqrt{1 + 4\sin^2\frac{x}{2} - 4\sin\frac{x}{2}}\,dx$ equals

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

(3) $4\sqrt{3} - 4 - \dfrac{\pi}{3}$ (4) $\pi - 4$

Answer (3)

Sol. $\displaystyle\int_0^{\pi} \sqrt{1 + 4\sin^2\frac{x}{2} - 4\sin\frac{x}{2}}\,dx$

$= \displaystyle\int_0^{\pi} \left|2\sin\frac{x}{2} - 1\right| dx$ $\quad \left[\begin{array}{l} \sin\dfrac{x}{2} = \dfrac{1}{2} \\ \Rightarrow \dfrac{x}{2} = \dfrac{\pi}{6} \to x = \dfrac{\pi}{3} \\ \dfrac{x}{2} = \dfrac{5\pi}{6} \to x = \dfrac{5\pi}{3} \end{array}\right]$

$= \displaystyle\int_0^{\pi/3} \left(1 - 2\sin\frac{x}{2}\right) dx + \int_{\pi/3}^{\pi} \left(2\sin\frac{x}{2} - 1\right) dx$

$= \left[x + 4\cos\dfrac{x}{2}\right]_0^{\pi/3} + \left[-4\cos\dfrac{x}{2} - x\right]_{\pi/3}^{\pi}$

$= \dfrac{\pi}{3} + 4\dfrac{\sqrt{3}}{2} - 4 + \left(0 - \pi + 4\dfrac{\sqrt{3}}{2} + \dfrac{\pi}{3}\right)$

$= 4\sqrt{3} - 4 - \dfrac{\pi}{3}$

22. If f and g are differentiable functions in [0, 1] satisfying $f(0) = 2 = g(1)$, $g(0) = 0$ and $f(1) = 6$, then for some $c \in]0, 1[$

(1) $2f'(c) = 3g'(c)$ (2) $f'(c) = g'(c)$

(3) $f'(c) = 2g'(c)$ (4) $2f'(c) = g'(c)$

Answer (3)

Sol. Using, mean value theorem

$f'(c) = \dfrac{f(1) - f(0)}{1 - 0} = 4$

$g'(c) = \dfrac{g(1) - g(0)}{1 - 0} = 2$

so, $\boxed{f'(c) = 2g'(c)}$

23. If g is the inverse of a function f and $f'(x) = \frac{1}{1+x^5}$, then $g'(x)$ is equal to

(1) $5x^4$ (2) $\frac{1}{1+\{g(x)\}^5}$

(3) $1 + \{g(x)\}^5$ (4) $1 + x^5$

Answer (3)

Sol. $f'(x) = \frac{1}{1+x^5} = f(g(x)) = x \rightarrow f'(g(x))\,g'(x) = 1$

$$g'(x) = \frac{1}{f'(g(x))} = 1 + (g(x))^5$$

24. If $(10)^9 + 2(11)^1 (10)^8 + 3(11)^2 (10)^7 + \ldots + 10(11)^9 = k(10)^9$, then k is equal to

(1) $\frac{441}{100}$ (2) 100

(3) 110 (4) $\frac{121}{10}$

Answer (2)

Sol. $10^9 + 2\cdot(11)(10)^8 + 3(11)^2(10)^7 + \ldots + 10(11)^9 = k(10)^9$

$x = 10^9 + 2\cdot(11)(10)^8 + 3(11)^2(10)^7 + \ldots + 10(11)^9$

$\frac{11}{10}x = 11\cdot10^8 + 2\cdot(11)^2\cdot(10)^7 + \ldots + 9(11)^9 + 11^{10}$

$x\left(1 - \frac{11}{10}\right) = 10^9 + 11(10)^8 + 11^2\times(10)^7 + \ldots + 11^9 - 11^{10}$

$$\Rightarrow -\frac{x}{10} = 10^9\left(\frac{\left(\frac{11}{10}\right)^{10} - 1}{\frac{11}{10} - 1}\right) - 11^{10}$$

$$\Rightarrow -\frac{x}{10} = (11^{10} - 10^{10}) - 11^{10} = -10^{10}$$

$\Rightarrow x = 10^{11} = k\cdot10^9$

$\Rightarrow k = 100$

25. If $\alpha, \beta \neq 0$, and $f(n) = \alpha^n + \beta^n$ and

$$\begin{vmatrix} 3 & 1+f(1) & 1+f(2) \\ 1+f(1) & 1+f(2) & 1+f(3) \\ 1+f(2) & 1+f(3) & 1+f(4) \end{vmatrix}$$

$= K(1 - \alpha)^2 (1 - \beta)^2 (\alpha - \beta)^2$, then K is equal to

(1) $\frac{1}{\alpha\beta}$ (2) 1

(3) -1 (4) $\alpha\beta$

Answer (2)

Sol.
$$\begin{vmatrix} 1\;1\;1 & 1 & 1\;\;{}^2\;\;{}^2 \\ 1 & 1\;\;{}^2\;\;{}^2 & 1\;\;{}^3\;\;{}^3 \\ 1\;\;{}^2\;\;{}^2 & 1\;\;{}^3\;\;{}^3 & 1\;\;{}^4\;\;{}^4 \end{vmatrix}$$

$$\begin{vmatrix} 1 & 1 & 1 \\ & & 1 \\ {}^2 & {}^2 & 1 \end{vmatrix} \begin{vmatrix} 1 & & {}^2 \\ 1 & & {}^2 \\ 1 & 1 & 1 \end{vmatrix}$$

$= [(1 - \alpha)(1 - \beta)(1 - \beta)]^2$

So, $\boxed{k = 1}$

26. The slope of the line touching both the parabolas $y^2 = 4x$ and $x^2 = -32y$ is

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

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

Answer (4)

Sol. $y^2 = 4x$ ...(1)

$x^2 = -32y$ ...(2)

m be slope of common tangent

Equation of tangent (1)

$y = mx + \frac{1}{m}$ ...(i)

Equation of tangent (2)

$y = mx + 8m^2$ ...(ii)

(i) and (ii) are identical

$\frac{1}{m} = 8m^2$

$\Rightarrow m^3 = \frac{1}{8}$

$\boxed{m = \frac{1}{2}}$

Alternative method :

Let tangent to y^2 $4x$ be

y mx $\frac{1}{m}$

as this is also tangent to x^2 $32y$

Solving x^2 $32mx$ $\frac{32}{m}$ 0

Since roots are equal

$\therefore$ $D = 0$

$(32)^2$ 4 $\frac{32}{m}$ 0

m^3 $\frac{4}{32}$

m $\frac{1}{2}$

27. The statement $\sim(p \leftrightarrow \sim q)$ is

(1) Equivalent to $\sim p \leftrightarrow q$

(2) A tautology

(3) A fallacy

(4) Equivalent to $p \leftrightarrow q$

Answer (4)

Sol. $\sim(p \leftrightarrow \sim q)$

p	q	$\sim q$	$p \leftrightarrow \sim q$	$\sim(p \leftrightarrow \sim q)$
F	F	T	F	T
F	T	F	T	F
T	F	T	T	F
T	T	F	F	T

Clearly equivalent to $p \leftrightarrow q$

28. Let the population of rabbits surviving at a time t be governed by the differential equation

$\frac{dp(t)}{dt} = \frac{1}{2}p(t) - 200$. If $p(0) = 100$, then $p(t)$ equals

(1) $300 - 200\,e^{-t/2}$ (2) $600 - 500\,e^{t/2}$

(3) $400 - 300\,e^{-t/2}$ (4) $400 - 300\,e^{t/2}$

Answer (4)

Sol. $$\frac{dp(t)}{dt} = \frac{1}{2}p(t) - 200$$

$$\int \frac{d(p(t))}{\left(\frac{1}{2}p(t) - 200\right)} = \int dt$$

$$2\log\left(\frac{p(t)}{2} - 200\right) = t + c$$

$$\frac{p(t)}{2} - 200 = e^{\frac{t}{2}}k$$

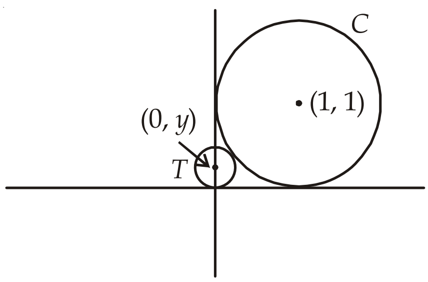
29. Let C be the circle with centre at (1, 1) and radius = 1. If T is the circle centred at (0, y), passing through origin and touching the circle C externally, then the radius of T is equal to

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

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

Answer (3)

Sol.



$C \equiv (x-1)^2 + (y-1)^2 = 1$

Radius of $T = |y|$

T touches C externally

$(0 - 1)^2 + (y - 1)^2 = (1 + |y|)^2$

$\Rightarrow 1 + y^2 + 1 - 2y = 1 + y^2 + 2|y|$

If $y > 0$,

$y^2 + 2 - 2y = y^2 + 1 + 2y$

$\Rightarrow 4y = 1$

$\Rightarrow y = \frac{1}{4}$

If $y < 0$,

$y^2 + 2 - 2y = y^2 + 1 - 2y$

$\Rightarrow 1 = 2$ (Not possible)

$\therefore y = \frac{1}{4}$

30. The angle between the lines whose direction cosines satisfy the equations $l + m + n = 0$ and $l^2 = m^2 + n^2$ is

(1) $\frac{\pi}{4}$ (2) $\frac{\pi}{6}$

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

Answer (4)

Sol. $l + m + n = 0$

$l^2 = m^2 + n^2$

Now, $(-m - n)^2 = m^2 + n^2$

$\Rightarrow mn = 0$

$m = 0$ or $n = 0$

If $m = 0$

then $l = -n$

$l^2 + m^2 + n^2 = 1$

Gives

$\Rightarrow n = \pm\frac{1}{\sqrt{2}}$

i.e. (l_1, m_1, n_1)

$= \left(-\frac{1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}}\right)$

If $n = 0$

then $l = -m$

$l^2 + m^2 + n^2 = 1$

$\Rightarrow 2m^2 = 1$

$\Rightarrow m^2 = \frac{1}{2}$

$\Rightarrow m = \pm\frac{1}{\sqrt{2}}$

Let $m = \frac{1}{\sqrt{2}}$

$l = -\frac{1}{\sqrt{2}}$

$n = 0$

(l_2, m_2, n_2)

$= \left(-\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0\right)$

$\therefore \cos\theta = \frac{1}{2}$

$\theta = \frac{\pi}{3}$

PART–B : PHYSICS

31. When a rubber-band is stretched by a distance x, it exerts a restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber-band by L is

(1) $\frac{1}{2}\ \frac{aL^2}{2}\ \frac{bL^3}{3}$ (2) $aL^2 + bL^3$

(3) $\frac{1}{2}(aL^2\ \ bL^3)$ (4) $\frac{aL^2}{2}\ \frac{bL^3}{3}$

Answer (4)

Sol. $dW\ \ F\ dl$

$W\ \ \int_0^L ax\,dx\ \ \int_0^L bx^2\,dx$

$\frac{aL^2}{2}\ \frac{bL^3}{3}.$

32. The coercivity of a small magnet where the ferromagnet gets demagnetized is 3×10^3 Am^{-1}. The current required to be passed in a solenoid of length 10 cm and number of turns 100, so that the magnet gets demagnetized when inside the solenoid, is

(1) 6 A   (2) 30 mA

(3) 60 mA   (4) 3 A

Answer (4)

Sol. $B = \mu_0\, n\, i$

$\frac{B}{_0}\ \ ni$

$3\ \ 10^3\ \ \frac{NI}{L}\ \ \frac{100\ \ i}{10\ \ 10^{\ 2}}$

$I = 3$ A.

33. In a large building, there are 15 bulbs of 40 W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of the electric mains is 220 V. The minimum capacity of the main fuse of the building will be

(1) 14 A   (2) 8 A

(3) 10 A   (4) 12 A

Answer (4)

Sol. $15 \times 40 + 5 \times 100 + 5 \times 80 + 1000 = V \times I$

$600 + 500 + 400 + 1000 = 220\ I$

$I\ \ \frac{2500}{220}\ \ 11.36$

$I = 12$ A.

34. An open glass tube is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now?

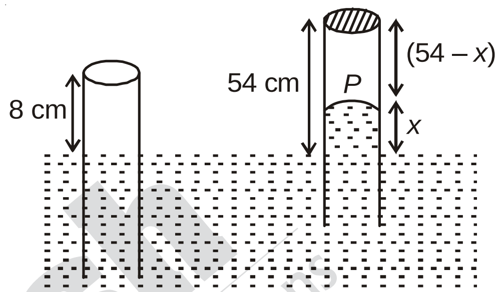
(Atmospheric pressure = 76 cm of Hg)

(1) 6 cm   (2) 16 cm

(3) 22 cm   (4) 38 cm

Answer (2)

Sol.



$P + x = P_0$

$P = (76 - x)$

$8 \times A \times 76 = (76 - x) \times A \times (54 - x)$

$x = 38$

Length of air column = 54 – 38 = 16 cm.

35. A bob of mass m attached to an inextensible string of length l is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed ω rad/s about the vertical. About the point of suspension

(1) Angular momentum changes both in direction and magnitude

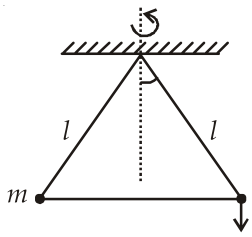
(2) Angular momentum is conserved

(3) Angular momentum changes in magnitude but not in direction

(4) Angular momentum changes in direction but not in magnitude

Answer (4)

Sol. $\tau = mg \times l \sin\theta$. (Direction parallel to plane of rotation of particle)



as τ is perpendicular to $\vec{L}$, direction of L changes but magnitude remains same.

36. The current voltage relation of diode is given by $I = (e^{1000V/T} - 1)$ mA, where the applied V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring ± 0.01 V while measuring the current of 5 mA at 300 K, what will be the error in the value of current in mA?

(1) 0.05 mA (2) 0.2 mA

(3) 0.02 mA (4) 0.5 mA

Answer (2)

Sol. $I = (e^{1000\,V/T} - 1)$mA

When I = 5 mA, $e^{1000\,V/T}$ = 6 mA

Also, $dI = (e^{1000\,V/T}) \times \frac{1000}{T} \cdot dV$

$= (6 \text{ mA}) \times \frac{1000}{300} \times (0.01)$

= 0.2 mA

37. From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is:

(1) $gH = (n - 2)u^2$ (2) $2\,gH = n^2u^2$

(3) $gH = (n - 2)^2u^2$ (4) $2\,gH = nu^2\,(n - 2)$

Answer (4)

Sol. Time taken to reach highest point is $t_1 = \frac{u}{g}$

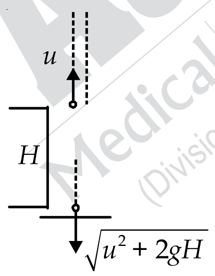
Speed on reaching ground $= \sqrt{u^2 + 2gh}$

Now, $v = u + at$

$\Rightarrow \sqrt{u^2 + 2gh} = -u + gt$

$\Rightarrow t = \frac{u + \sqrt{u^2 + 2gH}}{g} = \frac{nu}{g}$

$\Rightarrow 2gH = n(n-2)u^2$



38. A thin convex lens made from crown glass $\left(\mu = \frac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal lengths is

(1) f_1 and f_2 both become negative

(2) $f_1 = f_2 < f$

(3) $f_1 > f$ and f_2 becomes negative

(4) $f_2 > f$ and f_1 becomes negative

Answer (3)

Sol. By Lens maker's formula

$$\frac{1}{f_1} = \left(\frac{3/2}{4/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f_2} = \left(\frac{3/2}{5/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$\Rightarrow$ $f_1 = 4f$ & $f_2 = -5f$

39. A parallel plate capacitor is made of two circular plates separated by a distance 5 mm and with a dielectric of dielectric constant 2.2 between them. When the electric field in the dielectric is 3×10^4 V/m, the charge density of the positive plate will be close to

(1) 6×10^4 C/m^2 (2) 6×10^{-7} C/m^2

(3) 3×10^{-7} C/m^2 (4) 3×10^4 C/m^2

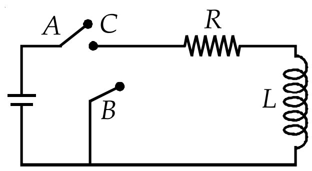
Answer (2)

Sol. $E = \frac{\sigma}{K\varepsilon_0}$

$\sigma = K\varepsilon_0 E$

$= 2.2 \times 8.85 \times 10^{-12} \times 3 \times 10^4 \approx 6 \times 10^{-7}$ C/m^2

40. In the circuit shown here, the point 'C' is kept connected to point 'A' till the current flowing through the circuit becomes constant. Afterward, suddenly, point 'C' is disconnected from point 'A' and connected to point 'B' at time $t = 0$. Ratio of the voltage across resistance and the inductor at $t = L/R$ will be equal to



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

(3) 1 (4) –1

Answer (4)

Sol. Applying Kirchhoff's law in closed loop, $-V_R - V_C = 0$

$\Rightarrow$ $V_R/V_C = -1$

Note : The sense of voltage drop has not been defined. The answer could have been 1.

41. Two beams, A and B, of plane polarized light with mutually perpendicular planes of polarization are seen through a polaroid. From the position when the beam A has maximum intensity (and beam B has zero intensity), a rotation of polaroid through 30° makes the two beams appear equally bright. If the initial intensities of the two beams are I_A and I_B respectively, then $\frac{I_A}{I_B}$ equals

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

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

Answer (1)

Sol. By law of Malus, $I = I_0\cos^2\theta$

Now, $I_{A'} = I_A\cos^2 30$

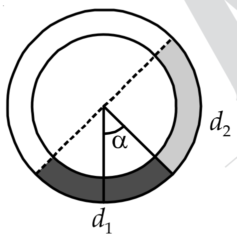
$I_{B'} = I_B\cos^2 60$

As $I_{A'} = I_{B'}$

$\Rightarrow \quad I_A \times \frac{3}{4} = I_B \times \frac{1}{4}$

$\frac{I_A}{I_B} = \frac{1}{3}$

42. There is a circular tube in a vertical plane. Two liquids which do not mix and of densities d_1 and d_2 are filled in the tube. Each liquid subtends 90° angle at centre. Radius joining their interface makes an angle α with vertical. Ratio $\frac{d_1}{d_2}$ is

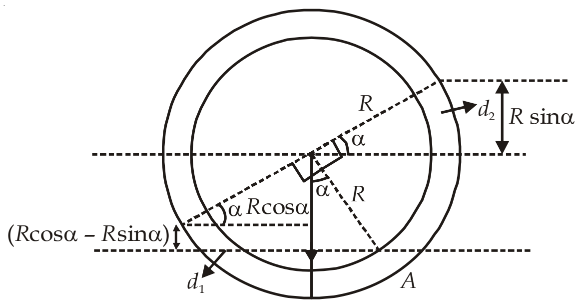


(1) $\frac{1+\sin\alpha}{1-\cos\alpha}$ (2) $\frac{1+\sin\alpha}{1-\sin\alpha}$

(3) $\frac{1+\cos\alpha}{1-\cos\alpha}$ (4) $\frac{1+\tan\alpha}{1-\tan\alpha}$

Answer (4)

Sol. Equating pressure at A



$(R\cos\alpha + R\sin\alpha)d_2g = (R\cos\alpha - R\sin\alpha)d_1g$

$\Rightarrow \frac{d_1}{d_2} = \frac{\cos\alpha + \sin\alpha}{\cos\alpha - \sin\alpha} = \frac{1+\tan\alpha}{1-\tan\alpha}$

43. The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is

(For steel Young's modulus is 2×10^{11} Nm^{-2} and coefficient of thermal expansion is 1.1×10^{-5} K^{-1})

(1) 2.2×10^6 Pa (2) 2.2×10^8 Pa

(3) 2.2×10^9 Pa (4) 2.2×10^7 Pa

Answer (2)

Sol. As length is constant,

Strain $= \frac{\Delta L}{L} = \alpha\Delta Q$

Now pressure = stress = Y × strain

$= 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100$

$= 2.2 \times 10^8$ Pa

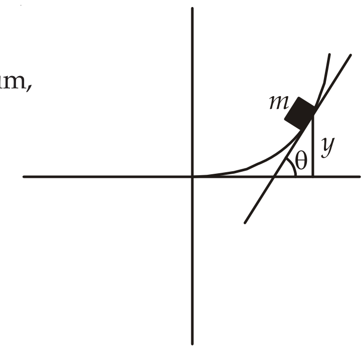
44. A block of mass m is placed on a surface with a vertical cross-section given by $y = \frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is

(1) $\frac{1}{2}$ m (2) $\frac{1}{6}$ m

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

Answer (2)

Sol. $\tan\theta = \frac{dy}{dx} = \frac{x^2}{2}$



At limiting equilibrium,

$\mu = \tan\theta$

$0.5 = \frac{x^2}{2}$

$\Rightarrow \quad x = \pm 1$

Now, $y = \frac{1}{6}$

45. Three rods of copper, brass and steel are welded together to form a Y-shaped structure. Area of cross-seciton of each rod = 4 cm^2. End of copper rod is maintained at 100°C whereas ends of brass and steel are kept at 0°C. Lengths of the copper, brass

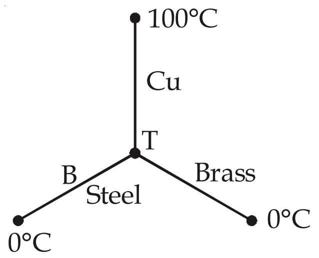
and steel rods are 46, 13 and 12 cm respectively. The rods are thermally insulated from surroundings except at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and 0.12 CGS units respectively. Rate of heat flow through copper rod is

(1) 6.0 cal/s (2) 1.2 cal/s

(3) 2.4 cal/s (4) 4.8 cal/s

Answer (4)

Sol.



$Q = Q_1 + Q_2$

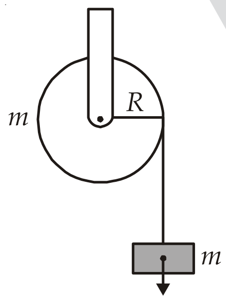
$$\frac{0.92\times4(100-T)}{46}=\frac{0.26\times4\times(T-0)}{13}+\frac{0.12\times4\times T}{12}$$

$\Rightarrow$ $200 - 2T = 2T + T$

$\Rightarrow$ $T = 40°C$

$\Rightarrow$ $Q=\frac{0.92\times4\times60}{46} = 4.8$ cal/s

46.. A mass m is supported by a massless string wound around a uniform hollow cylinder of mass m and radius R. If the string does not slip on the cylinder, with what acceleration will the mass fall on release?



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

(3) $\frac{g}{2}$ (4) $\frac{5g}{6}$

Answer (3)

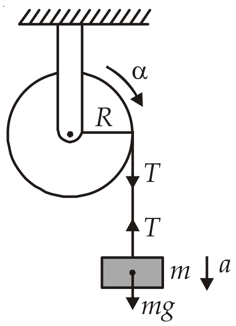
Sol. $a = R\alpha$

$mg - T = ma$

$T \times R = mR^2\alpha$

or $T = ma$

$\Rightarrow$ $a=\frac{g}{2}$



47. Match **List-I** (Electromagnetic wave type) with **List - II** (Its association/application) and select the correct option from the choices given below the lists

List-I		**List-II**	
(a)	Infrared waves	(i)	To treat muscular strain
(b)	Radio waves	(ii)	For broadcasting
(c)	X-rays	(iii)	To detect fracture of bones
(d)	Ultraviolet rays	(iv)	Absorbed by the ozone layer of the atmosphere

	(a)	**(b)**	**(c)**	**(d)**
(1)	(i)	(ii)	(iii)	(iv)
(2)	(iv)	(iii)	(ii)	(i)
(3)	(i)	(ii)	(iv)	(iii)
(4)	(iii)	(ii)	(i)	(iv)

Answer (1)

Sol. (a) Infrared rays are used to treat muscular strain

(b) Radiowaves are used for broadcasting

(c) X-rays are used to detect fracture of bones

(d) Ultraviolet rays are absorbed by ozone

48. The radiation corresponding to 3→2 transition of hydrogen atoms falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to

(1) 1.6 eV (2) 1.8 eV

(3) 1.1 eV (4) 0.8 eV

Answer (3)

Sol. $r=\frac{mv}{qB}=\frac{\sqrt{2meV}}{eB}=\frac{1}{B}\sqrt{\frac{2m}{e}V}$

$\Rightarrow$ $V=\frac{B^2r^2e}{2m} = 0.8$ V

For transition between 3 to 2,

$$E=13.6\left(\frac{1}{4}-\frac{1}{9}\right)$$

$$=\frac{13.6\times5}{36}$$

$= 1.88$ eV

Work function $= 1.88$ eV $- 0.8$ eV

$= 1.08$ eV $= 1.1$ eV

49. During the propagation of electromagnetic waves in a medium

(1) Both electric and magnetic energy densities are zero

(2) Electric energy density is double of the magnetic energy density

(3) Electric energy density is half of the magnetic energy density

(4) Electric energy density is equal to the magnetic energy density

Answer (4)

Sol. Energy is equally divided between electric and magnetic field

50. A green light is incident from the water to the air - water interface at the critical angle(θ). Select the **correct** statement

(1) The entire spectrum of visible light will come out of the water at various angles to the normal

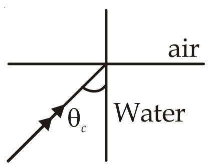
(2) The entire spectrum of visible light will come out of the water at an angle of 90° to the normal

(3) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium

(4) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium

Answer (3)

Sol. $\sin\theta_c = \frac{1}{\mu}$



For greater wavelength (i.e. lesser frequency) μ is less

So, θ_c would be more. So, they will not suffer reflection and come out at angles less then 90°.

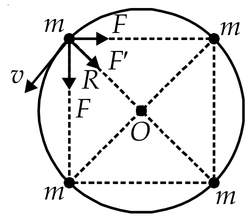
51. Four particles, each of mass M and equidistant from each other, move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is

(1) $\frac{1}{2}\sqrt{\frac{GM}{R}(1\quad 2\sqrt{2})}$ (2) $\sqrt{\frac{GM}{R}}$

(3) $\sqrt{2\sqrt{2}\frac{GM}{R}}$ (4) $\sqrt{\frac{GM}{R}(1\quad 2\sqrt{2})}$

Answer (1)

Sol. $\frac{F}{\sqrt{2}}+\frac{F}{\sqrt{2}}+F' = \frac{mv^2}{R}$



$$\frac{2\times Gm^2}{\sqrt{2}(R\sqrt{2})^2}+\frac{Gm^2}{4R^2} = \frac{mv^2}{R}$$

$$\frac{Gm^2}{R}\left[\frac{1}{4}+\frac{1}{\sqrt{2}}\right] = mv^2$$

$$v = \sqrt{\frac{Gm}{R}\left(\frac{\sqrt{2}+4}{4\sqrt{2}}\right)}$$

$$= \frac{1}{2}\sqrt{\frac{Gm}{R}\left(1+2\sqrt{2}\right)}$$

52. A particle moves with simple harmonic motion in a straight line. In first τ s, after starting from rest it travels a distance a, and in next τ s it travels $2a$ in same direction then

(1) Time period of oscillations is 6τ

(2) Amplitude of motion is $3a$

(3) Time period of oscillations is 8τ

(4) Amplitude of motion is $4a$

Answer (1)

Sol. As it starts from rest, we have

$x = A\cos\omega t$. At $t = 0$, $x = A$

when $t = \tau$, $x = A - a$

when $t = 2\tau$, $x = A - 3a$

$\Rightarrow A - a = A\cos\omega\tau$

$A - 3a = A\cos 2\omega\tau$

As $\cos 2\omega\tau = 2\cos^2\omega\tau - 1$

$$\Rightarrow \frac{A-3a}{A} = 2\left(\frac{A-a}{A}\right)^2 - 1$$

$$\frac{A-3a}{A} = \frac{2A^2+2a^2-4Aa-A^2}{A^2}$$

$A^2 - 3aA = A^2 + 2a^2 - 4Aa$

$a^2 = 2aA$

$A = 2a$

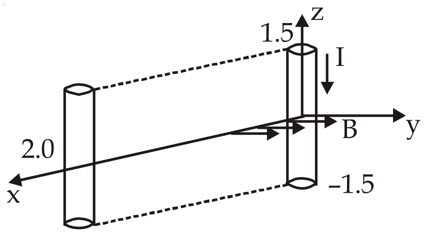
Now, $A - a = A\cos\omega\tau$

$$\Rightarrow \cos\omega\tau = \frac{1}{2}$$

$$\frac{2\pi}{T}\tau = \frac{\pi}{3}$$

$\Rightarrow T = 6\tau$

53. A conductor lies along the z-axis at $-1.5 \le z < 1.5$ m and carries a fixed current of 10.0 A in $-\hat{a}_z$ direction (see figure). For a field $\vec{B}\ \ 3.0\ \ 10^{\ 4}\ e^{-0.2x}\ \hat{a}_y$ T, find the power required to move the conductor at constant speed to x = 2.0 m, y = 0 m in 5 × 10^{-3} s. Assume parallel motion along the x-axis



(1) 29.7 W
(2) 1.57 W
(3) 2.97 W
(4) 14.85 W

Answer (3)

Sol. Average Power = $\dfrac{\text{work}}{\text{time}}$

$$W = \int_0^2 F dx$$

$$= \int_0^2 3.0\times10^{-4} e^{-0.2x} \times 10 \times 3\ dx$$

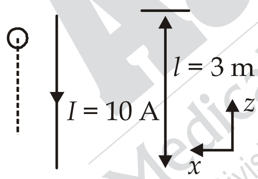
$$= 9\times10^{-3}\int_0^2 e^{-0.2x}\ dx$$

$$= \frac{9\times10^{-3}}{0.2}\left[-e^{-0.2\times2}+1\right]$$

$$= \frac{9\times10^{-3}}{0.2}\times\left[1-e^{-0.4}\right]$$

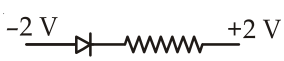
$= 9 \times 10^{-3} \times (0.33)$

$= 2.97 \times 10^{-3}$ J

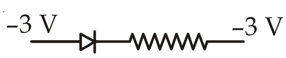


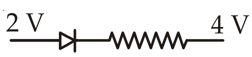
$$P = \frac{2.97\times10^{-3}}{(0.2)\times5\times10^{-3}} = 2.97\ \text{W}$$

54. The forward biased diode connection is

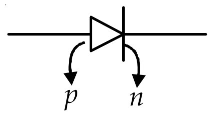
(1) 

(2) 

(3) 

(4) 

Answer (2)

Sol. 

For forward Bias, p-side must be at higher potential than n-side.

55. Hydrogen $({}_1H^1)$, Deuterium $({}_1H^2)$, singly ionised Helium $({}_2He^4)^+$ and doubly ionised lithium $({}_3Li^6)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wave lengths of emitted radiation are λ_1, λ_2, λ_3 and λ_4 respectively then approximately which one of the following is **correct**?

(1) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

(2) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

(3) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

(4) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

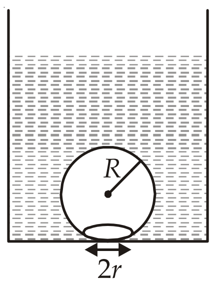
Answer (4)

Sol. $\dfrac{1}{\lambda} = RZ^2\left[\dfrac{1}{n_1^2} - \dfrac{1}{n^2}\right]$

$\Rightarrow\ \lambda \propto \dfrac{1}{Z^2}$ for given n_1 & n_2

$\Rightarrow\ \lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

56. On heating water, bubbles being formed at the bottom of the vessel detatch and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If $r << R$, and the surface tension of water is T, value of r just before bubbles detatch is (Density of water is ρ_w)



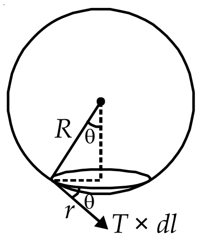
(1) $R^2\sqrt{\dfrac{3\rho_w g}{T}}$
(2) $R^2\sqrt{\dfrac{\rho_w g}{3T}}$

(3) $R^2\sqrt{\dfrac{\rho_w g}{6T}}$
(4) $R^2\sqrt{\dfrac{\rho_w g}{T}}$

Answer (No answer)

Sol. When the bubble gets detached,

Buoyant force = force due to surface tension



$$\int T \times dl \sin\theta = \frac{4}{3}\pi R^3 \rho_w g$$

$$\Rightarrow \quad T \times 2\pi r \times \frac{r}{R} = \frac{4}{3}\pi R^3 \rho_w g$$

$$\Rightarrow \quad r^2 = \frac{2R^4 \rho_w g}{3}$$

$$\Rightarrow \quad r = R^2\sqrt{\frac{2\rho_w g}{3T}}$$

57. A pipe of length 85 cm is closed from one end. Find the number of possible natural oscillations of air column in the pipe whose frequencies lie below 1250 Hz. The velocity of sound in air is 340 m/s.

(1) 4 (2) 12

(3) 8 (4) 6

Answer (4)

Sol. $f = \frac{(2n-1)v}{4L} \le 1250$

$$\Rightarrow \quad \frac{(2n-1)\times 340}{0.85 \times 4} \le 1250$$

$\Rightarrow$ $2n - 1 \le 12.5$

$\therefore$ Answer is 6.

58. Assume that an electric field $\vec{E} = 30x^2\hat{i}$ exists in space. Then the potential difference $V_A - V_O$, where V_O is the potential at the origin and V_A the potential at $x = 2$ m is

(1) 80 J (2) 120 J

(3) –120 J (4) –80 J

Answer (4)

Sol. $dV = -\vec{E}\cdot\vec{dx}$

$$\int_{V_O}^{V_A} dV = -\int_0^2 30x^2\,dx$$

$$V_A - V_O = -[10x^3]_0^2 = -80 \text{ V}$$

59. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it?

(1) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm

(2) A meter scale

(3) A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm

(4) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm

Answer (3)

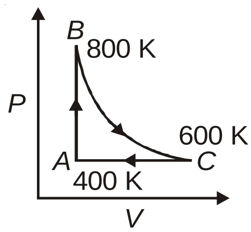
Sol. As measured value is 3.50 cm, the least count must be 0.01 cm = 0.1 mm

For vernier scale with 1 MSD = 1 mm and 9 MSD = 10 VSD,

Least count = 1 MSD – 1 VSD

= 0.1 mm

60. One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B and C are 400 K, 800 K and 600 K respectively. Choose the correct statement



(1) The change in internal energy in the process BC is – $500R$

(2) The change in internal energy in whole cyclic process is $250R$

(3) The change in internal energy in the process CA is $700R$

(4) The change in internal energy in the process AB is $-350R$

Answer (1)

Sol. $\Delta U = nC_V\Delta T = 1 \times \frac{5R}{2}\Delta T$

For BC, $\Delta T = -200$ K

$\Rightarrow$ $\Delta U = -500R$

PART–C : CHEMISTRY

61. Which one is classified as a condensation polymer?

(1) Acrylonitrile

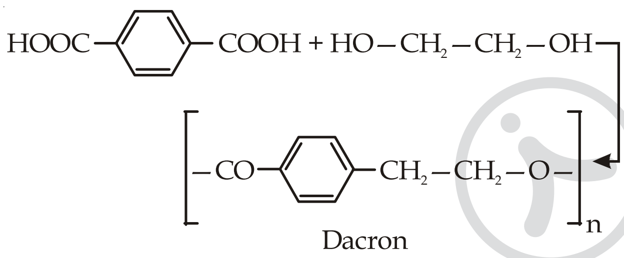
(2) Dacron

(3) Neoprene

(4) Teflon

Answer (2)

Sol. Dacron is polyester formed by condensation polymerisation of terephthalic acid and ethylene glycol.



Acrylonitrile, Neoprene and Teflon are addition polymers of acrylonitrile, isoprene and tetrafluoro ethylene respectively.

62. Which one of the following properties is **not** shown by NO?

(1) It's bond order is 2.5

(2) It is diamagnetic in gaseous state

(3) It is a neutral oxide

(4) It combines with oxygen to form nitrogen dioxide

Answer (2)

Sol. Nitric oxide is paramagnetic in the gaseous state as it has one unpaired electron in its outermost shell. The electronic configuration of NO is

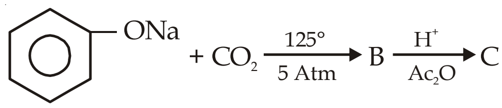
$$\sigma^2_{1s}\sigma^{*2}_{1s}\sigma^2_{2s}\sigma^{*2}_{2s}\sigma^2_{2p_z}\pi^2_{2p_x} = \pi^2_{2p_y}\pi^{*1}_{2p_x}$$

However, it dimerises at low temperature to become diamagnetic.

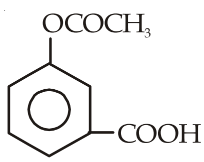
$$2NO \rightleftharpoons N_2O_2$$

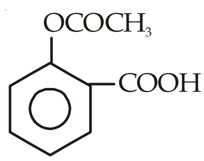
Its bond order is 2.5 and it combines with O_2 to give nitrogen dioxide.

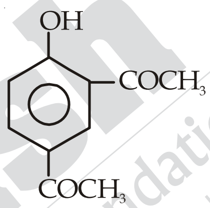
63. Sodium phenoxide when heated with CO_2 under pressure at 125°C yields a product which on acetylation produces C.

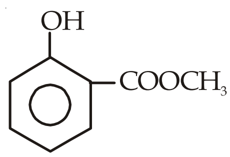


The major product C would be

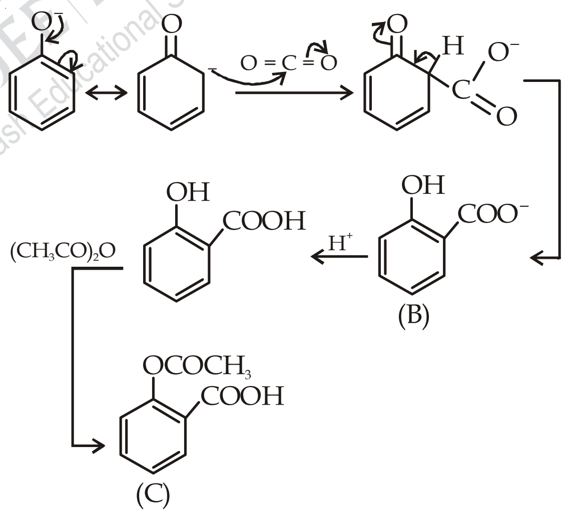
(1) 

(2) 

(3) 

(4) 

Answer (2)

Sol. 

64. Given below are the half-cell reactions

$Mn^{2+} + 2e^- \rightarrow Mn$; E° = – 1.18 V

$(Mn^{3+} + e^- \rightarrow Mn^{2+})$; E° = + 1.51 V

The E° for $3Mn^{2+} \rightarrow Mn + 2Mn^{3+}$ will be

(1) –0.33 V; the reaction will occur

(2) –2.69 V; the reaction will not occur

(3) –2.69 V; the reaction will occur

(4) –0.33 V; the reaction will not occur

Answer (2)

Sol. (1) $Mn^{2+} + 2e \rightarrow Mn$; $E° = -1.18V$;

$$\Delta G_1^\circ = -2F(-1.18) = 2.36F$$

(2) $Mn^{3+} + e \rightarrow Mn^{2+}$; $E° = +1.51$ V;

$$\Delta G_2^\circ = -F(1.51) = -1.51\,F$$

(1) – 2 × (2)

$3Mn^{2+} \rightarrow Mn + 2Mn^{3+}$;

$$\Delta G_3^\circ = \Delta G_1^\circ - 2\Delta G_2^\circ$$

$= [2.36 - 2(-1.51)]$ F

$= (2.36 + 3.02)$ F

$= 5.38$ F

But $\Delta G_3^\circ = -2FE°$

$\Rightarrow$ 5.38F = –2FE°

$\Rightarrow$ E° = –2.69 V

As E° value is negative reaction is non spontaneous.

65. For complete combustion of ethanol,

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$,

the amount of heat produced as measured in bomb calorimeter, is 1364.47 kJ mol^{-1} at 25°C. Assuming ideality the enthalpy of combustion, Δ_cH, for the reaction will be (R = 8.314 kJ mol^{-1})

(1) –1350.50 kJ mol^{-1}

(2) –1366.95 kJ mol^{-1}

(3) –1361.95 kJ mol^{-1}

(4) –1460.50 kJ mol^{-1}

Answer (2)

Sol. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Bomb calorimeter gives ΔU of the reaction

So, as per question

ΔU = –1364.47 kJ mol^{-1}

$\Delta n_g = -1$

$\Delta H = \Delta U + \Delta n_g RT$

$$= -1364.47 - \frac{1 \times 8.314 \times 298}{1000}$$

= –1366.93 kJ mol^{-1}

66. For the estimation of nitrogen, 1.4 g of an organic compound was digested by Kjeldahl method and the evolved ammonia was absorbed in 60 mL of $\frac{M}{10}$ sulphuric acid. The unreacted acid required 20 mL of $\frac{M}{10}$ sodium hydroxide for complete neutralization. The percentage of nitrogen in the compound is

(1) 5%   (2) 6%

(3) 10%   (4) 3%

Answer (3)

Sol. As per question

	Normality	Volume
H_2SO_4	$\frac{N}{5}$	60mL
NaOH	$\frac{N}{10}$	20mL

$$(n_{geq})_{H_2SO_4} = (n_{geq})_{NaOH} + (n_{geq})_{NH_3}$$

$$\frac{1}{5} \times \frac{60}{1000} = \frac{1}{10} \times \frac{20}{1000} + (n_{geq})_{NH_3}$$

$$\frac{6}{500} = \frac{1}{500} + (n_{geq})_{NH_3}$$

$$(n_{geq})_{NH_3} = \frac{5}{500} = \frac{1}{100}$$

$$(n_{mol})_N = (n_{mol})_{NH_3} = (n_{geq})_{NH_3} = \frac{1}{100}$$

$$(Mass)_N = \frac{14}{100} = 0.14\,g$$

$$\text{Percentage of "N"} = \frac{0.14}{1.4} \times 100 = 10\%$$

67. The major organic compound formed by the reaction of 1, 1, 1-trichloroethane with silver powder is

(1) 2-Butene   (2) Acetylene

(3) Ethene   (4) 2-Butyne

Answer (4)

Sol. $2Cl{-}\underset{Cl}{\overset{Cl}{C}}{-}CH_3 \xrightarrow{Ag} CH_3C \equiv CCH_3 + 6AgCl$

1, 1, 1-trichloroethane

68. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is

(1) 3 : 16 (2) 1 : 4

(3) 7 : 32 (4) 1 : 8

Answer (3)

Sol. Let the mass of O_2 = x

Mass of N_2 = 4x

Number of moles of $O_2 = \frac{x}{32}$

Number of moles of $N_2 = \frac{4x}{28} = \frac{x}{7}$

$\therefore$ Ratio $= \frac{x}{32} : \frac{x}{7} = 7 : 32$

69. The metal that cannot be obtained by electrolysis of an aqueous solution of its salts is

(1) Cr (2) Ag

(3) Ca (4) Cu

Answer (3)

Sol. On electrolysis only in case of Ca^{2+} salt aqueous solution H_2 gas discharge at Cathode.

Case of Cr

At cathode : $Cr^{3+} + 2e^- \longrightarrow Cr$

So, Cr is deposited.

Case of Ag

At cathode : $Ag^+ + e^- \longrightarrow Ag$

So, Ag is deposited.

Case of Cu

At cathode : $Cu^{2+} + 2e^- \longrightarrow Cu$

Case of Ca^{2+}

At cathode : $H_2O + e^- \longrightarrow \frac{1}{2}H_2 + OH^-$

70. The equivalent conductance of NaCl at concentration C and at infinite dilution are λ_C and λ_∞, respectively. The correct relationship between λ_C and λ_∞ is given as

(Where the constant B is positive)

(1) C (B)$\sqrt{C}$

(2) C (B)C

(3) C $-$(B)C

(4) C $-$(B)$\sqrt{C}$

Answer (4)

Sol. According to Debye Huckle onsager equation,

$$\lambda_C = \lambda_\infty - A\sqrt{C}$$

Here A = B

$$\therefore \quad \lambda_C = \lambda_\infty - B\sqrt{C}$$

71. The correct set of four quantum numbers for the valence electrons of rubidium atom (Z = 37) is

(1) $5, 0, 1, +\frac{1}{2}$ (2) $5, 0, 0, +\frac{1}{2}$

(3) $5, 1, 0, +\frac{1}{2}$ (4) $5, 1, 1, +\frac{1}{2}$

Answer (2)

Sol. $37 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^1$

So last electron enters 5s orbital

Hence $n = 5, l = 0, m_l = 0, m_s = \pm\frac{1}{2}$

72. Consider separate solutions of 0.500 M C_2H_5OH(aq), 0.100 M $Mg_3(PO_4)_2$(aq), 0.250 M KBr(aq) and 0.125 M Na_3PO_4(aq) at 25°C. Which statement is **true** about these solutions, assuming all salts to be strong electrolytes?

(1) 0.500 M C_2H_5OH(aq) has the highest osmotic pressure.

(2) They all have the same osmotic pressure.

(3) 0.100 M $Mg_3(PO_4)_2$(aq) has the highest osmotic pressure.

(4) 0.125 M Na_3PO_4(aq) has the highest osmotic pressure.

Answer (2)

Sol. $\pi = i\,CRT$

$$\pi_{C_2H_5OH} = 1 \times 0.500 \times R \times T = 0.5\,RT$$

$$\pi_{Mg_3(PO_4)_2} = 5 \times 0.100 \times R \times T = 0.5\,RT$$

KBr 2 0.250 R T 0.5 RT

Na_3PO_4 4 0.125 RT 0.5 RT

73. The most suitable reagent for the conversion of $R - CH_2 - OH \rightarrow R - CHO$ is

(1) PCC (Pyridinium Chlorochromate)

(2) $KMnO_4$

(3) $K_2Cr_2O_7$

(4) CrO_3

Answer (1)

Sol. PCC is mild oxidising agent, it will convert

$R-CH_2-OH \longrightarrow R-CHO$

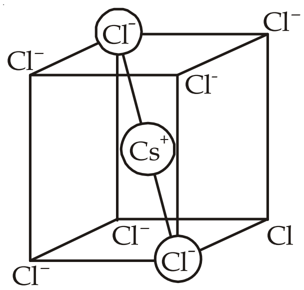
74. CsCl crystallises in body centred cubic lattice. If 'a' is its edge length then which of the following expressions is correct?

(1) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$ (2) $r_{Cs^+} + r_{Cl^-} = 3a$

(3) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$ (4) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$

Answer (4)

Sol.



$2r_{Cl^-} + 2r_{Cs^+} = \sqrt{3}\ a$

$r_{Cl^-} + r_{Cs^+} = \frac{\sqrt{3}a}{2}$

75. In which of the following reactions H_2O_2 acts as a reducing agent?

(a) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$

(b) $H_2O_2 - 2e^- \rightarrow O_2 + 2H^+$

(c) $H_2O_2 + 2e^- \rightarrow 2OH^-$

(d) $H_2O_2 + 2OH^- - 2e^- \rightarrow O_2 + 2H_2O$

(1) (b), (d)

(2) (a), (b)

(3) (c), (d)

(4) (a), (c)

Answer (1)

Sol. The reducing agent oxidises itself.

(a) $H_2O_2^{-1} + 2H^+ + 2e^- \longrightarrow 2H_2O^{-2}$

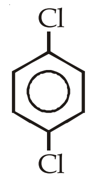
(b) $H_2O_2^{-1} - 2e \longrightarrow \overset{0}{O_2} + 2H^+$

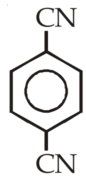
(c) $H_2O_2^{-1} + 2e \longrightarrow 2\overset{-2}{O}H^-$

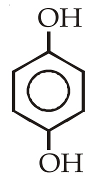
(d) $H_2O_2^{-1} + 2OH^- - 2e \longrightarrow \overset{0}{O_2} + H_2O$

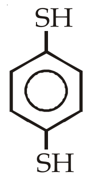
Note : Powers of 'O' are oxidation number of 'O' in the compound.

76. For which of the following molecule significant $\mu \neq 0$?

(a) 

(b) 

(c) 

(d) 

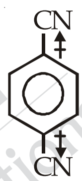
(1) (c) and (d) (2) Only (a)

(3) (a) and (b) (4) Only (c)

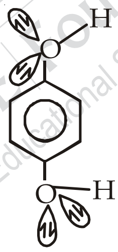
Answer (1)

Sol. (a) 

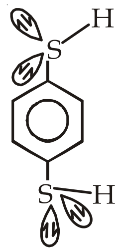
$\mu = 0$

(b) 

$\mu = 0$

(c) 

$\mu \neq 0$

(d) 

$\mu \neq 0$

77. On heating an aliphatic primary amine with chloroform and ethanolic potassium hydroxide, the organic compound formed is

(1) An alkyl isocyanide (2) An alkanol

(3) An alkanediol (4) An alkyl cyanide

Answer (1)

Sol. $R - CH_2 - NH_2 \xrightarrow[C_2H_5OH]{CHCl_3/KOH} R - CH_2 - NC$

78. In S_N2 reactions, the correct order of reactivity for the following compounds

CH_3Cl, CH_3CH_2Cl, $(CH_3)_2CHCl$ and $(CH_3)_3CCl$ is

(1) $(CH_3)_2CHCl > CH_3CH_2Cl > CH_3Cl > (CH_3)_3CCl$

(2) $CH_3Cl > (CH_3)_2CHCl > CH_3CH_2Cl > (CH_3)_3CCl$

(3) $CH_3Cl > CH_3CH_2Cl > (CH_3)_2CHCl > (CH_3)_3CCl$

(4) $CH_3CH_2Cl > CH_3Cl > (CH_3)_2CHCl > (CH_3)_3CCl$

Answer (3)

Sol. Rate of S_N2 reaction depends on steric crowding of alkyl halide. So order is

$CH_3Cl > (CH_3)CH_2 - Cl > (CH_3)_2CH - Cl > (CH_3)_3CCl$

79. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorb wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is

(1) $L_1 < L_2 < L_4 < L_3$

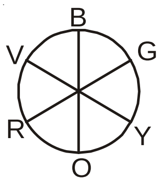
(2) $L_4 < L_3 < L_2 < L_1$

(3) $L_1 < L_3 < L_2 < L_4$

(4) $L_3 < L_2 < L_4 < L_1$

Answer (3)

Sol.



The energy of red light is less than that of violet light.

So energy order is

Red < Yellow < Green < Blue

The complex absorbs lower energy light lower will be its strength. So order of ligand strength is

$L_1 < L_3 < L_2 < L_4$

80. The equation which is balanced and represents the correct product(s) is

(1) $CuSO_4 + 4KCN \rightarrow K_2[Cu(CN)_4] + K_2SO_4$

(2) $Li_2O + 2KCl \rightarrow 2LiCl + K_2O$

(3) $[CoCl(NH_3)_5]^+ + 5H^+ \rightarrow Co^{2+} + 5NH_4^+ + Cl^-$

(4) $[Mg(H_2O)_6]^{2+} + (EDTA)^{4-} \xrightarrow{\text{excess NaOH}} [Mg(EDTA)]^{2+} + 6H_2O$

Answer (3)

Sol. The complex

$[CoCl(NH_3)_5]^+$ decomposes under acidic medium, so

$[CoCl(NH_3)_5]^+ + 5H^+ \rightarrow Co^{2+} + 5NH_4^+ + Cl^-$.

81. In the reaction,

$$CH_3COOH \xrightarrow{LiAlH_4} A \xrightarrow{PCl_5} B \xrightarrow{Alc.KOH} C,$$

the product C is

(1) Acetyl chloride

(2) Acetaldehyde

(3) Acetylene

(4) Ethylene

Answer (4)

Sol. Ethylene

$$CH_3COOH \xrightarrow{LiAlH_4} CH_3CH_2OH \quad \text{'A'}$$

$$\downarrow PCl_5$$

$$CH_3CH_2Cl \quad \text{'B'}$$

$$\downarrow \text{Alc. KOH}$$

$$CH_2 = CH_2 \quad \text{'C'}$$

82. The correct statement for the molecule, CsI_3, is

(1) It contains Cs^+, I^- and lattice I_2 molecule

(2) It is a covalent molecule

(3) It contains Cs^+ and I_3^- ions

(4) It contains Cs^{3+} and I^- ions

Answer (3)

Sol. It contains Cs^+ and I_3^- ions

83. For the reaction $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$, if $K_P = K_C(RT)^x$ where the symbols have usual meaning then the value of x is (assuming ideality)

(1) 1 (2) –1

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

Answer (3)

Sol. $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$

$K_P = K_C(RT)^x$

$x = \Delta n_g$ = no. of gaseous moles in product – no. of gaseous moles in reactant

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

84. For the non-stoichiometre reaction $2A + B \rightarrow C + D$, the following kinetic data were obtained in three separate experiments, all at 298 K.

Initial Concentration (A)	Initial Concentration (B)	Initial rate of formation of C ($mol\ L^{-1}s^{-1}$)
0.1 M	0.1 M	1.2×10^{-3}
0.1 M	0.2 M	1.2×10^{-3}
0.2 M	0.1 M	2.4×10^{-3}

The rate law for the formation of C is

(1) $\frac{dc}{dt} = k[A]$

(2) $\frac{dc}{dt} = k[A][B]$

(3) $\frac{dc}{dt} = k[A]^2 [B]$

(4) $\frac{dc}{dt} = k[A][B]^2$

Answer (1)

Sol. $2A + B \longrightarrow C + D$

Rate of Reaction = $\frac{-1}{2}\frac{d[A]}{dt} = -\frac{d[B]}{dt}$

$= \frac{d[C]}{dt} = \frac{d[D]}{dt}$

Let rate of Reaction = $k[A]^x[B]^y$

Or, $\frac{d[C]}{dt} \quad k[A]^x[B]^y$

Now from table,

$1.2 \times 10^{-3} = k\,[0.1]^x[0.1]^y$ ...(i)

$1.2 \times 10^{-3} = k\,[0.1]^x[0.2]^y$ ...(ii)

$2.4 \times 10^{-3} = k\,[0.2]^x[0.1]^y$ ...(iii)

Dividing equation (i) by (ii)

$\Rightarrow \quad \frac{1.2 \quad 10^{\ 3}}{1.2 \quad 10^{\ 3}} \quad \frac{k[0.1]^x[0.1]^y}{k[0.1]^x[0.2]^y}$

$\Rightarrow \quad 1 = \left[\frac{1}{2}\right]^y$

$\Rightarrow \quad \boxed{y = 0}$

Now Dividing equation (i) by (iii)

$\Rightarrow \quad \frac{1.2 \quad 10^{\ 3}}{2.4 \quad 10^{\ 3}} \quad \frac{k[0.1]^x[0.1]^y}{k[0.2]^x[0.1]^y}$

$\Rightarrow \quad \left[\frac{1}{2}\right]^1 = \left[\frac{1}{2}\right]^x$

$\Rightarrow \quad \boxed{x = 1}$

Hence $\frac{d[C]}{dt} = k[A]^1[B]^0$.

85. Resistance of 0.2 M solution of an electrolyte is 50 Ω. The specific conductance of the solution is 1.4 S m^{-1}. The resistance of 0.5 M solution of the same electrolyte is 280 Ω. The molar conductivity of 0.5 M solution of the electrolyte in S m^2 mol^{-1} is

(1) 5×10^2 (2) 5×10^{-4}

(3) 5×10^{-3} (4) 5×10^3

Answer (2)

Sol. For 0.2 M solution

R = 50 Ω

$\sigma = 1.4\ S\ m^{-1} = 1.4 \times 10^{-2}\ S\ cm^{-1}$

$\Rightarrow \quad \rho = \frac{1}{\sigma} = \frac{1}{1.4 \times 10^{-2}}\ \Omega\,cm$

Now, $R = \rho\frac{l}{a}$

$\Rightarrow \quad \frac{l}{a} = \frac{R}{\rho} = 50 \times 1.4 \times 10^{-2}$

For 0.5 M solution

R = 280 Ω

σ = ?

$\frac{l}{a} = 50 \times 1.4 \times 10^{-2}$

$\Rightarrow \quad R = \rho\frac{l}{a}$

$\Rightarrow \quad \frac{1}{\rho} = \frac{1}{R} \times \frac{l}{a}$

$\Rightarrow \quad \sigma = \frac{1}{280} \times 50 \times 1.4 \times 10^{-2}$

$= \frac{1}{280} \times 70 \times 10^{-2}$

$= 2.5 \times 10^{-3}\ S\ cm^{-1}$

Now, $\lambda_m = \frac{\sigma \times 1000}{M}$

$= \frac{2.5 \times 10^{-3} \times 1000}{0.5}$

$= 5\ S\ cm^2\ mol^{-1}$

$= 5 \times 10^{-4}\ S\ m^2\ mol^{-1}$

86. Among the following oxoacids, the correct decreasing order of acid strength is

(1) $HClO_2 > HClO_4 > HClO_3 > HOCl$

(2) $HOCl > HClO_2 > HClO_3 > HClO_4$

(3) $HClO_4 > HOCl > HClO_2 > HClO_3$

(4) $HClO_4 > HClO_3 > HClO_2 > HOCl$

Answer (4)

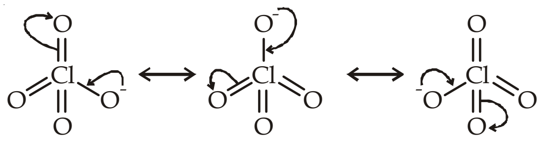
Sol. $HClO_4 \rightleftharpoons ClO_4^- + H^+$

$HClO_3 \rightleftharpoons ClO_3^- + H^+$

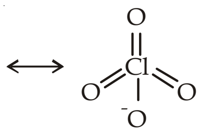
$HClO_2 \rightleftharpoons ClO_2^- + H^+$

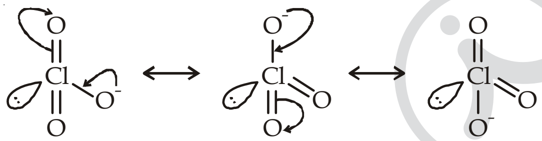
$HOCl \rightleftharpoons ClO^- + H^+$

Resonance produced conjugate base.

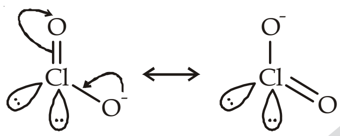
(i) 

(ClO_4^-)



(ii) 

(ClO_3^-)

(iii) 

(ClO_2^-)

(iv) ClO^- is not resonance stabilized.

As per resonance stability order of conjugate base is

$ClO_4^- > ClO_3^- > ClO_2^- > ClO^-$

Hence acidic strength order is

$HClO_4 > HClO_3 > HClO_2 > HClO$

87. Which one of the following bases is **not** present in DNA?

(1) Thymine (2) Quinoline

(3) Adenine (4) Cytosine

Answer (2)

Sol. DNA contains ATGC bases

A – Adenine

T – Thymine

G – Guanine

C – Cytocine

So quinoline is not present.

88. Considering the basic strength of amines in aqueous solution, which one has the smallest pK_b value?

(1) $C_6H_5NH_2$

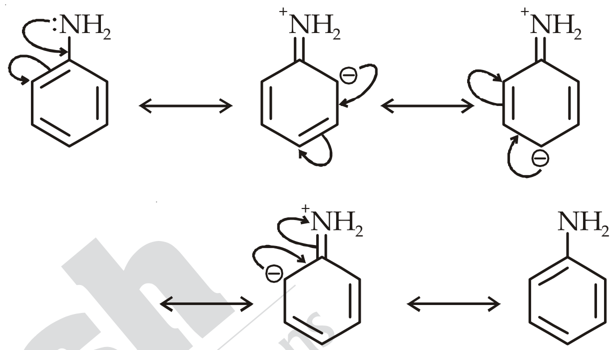
(2) $(CH_3)_2NH$

(3) CH_3NH_2

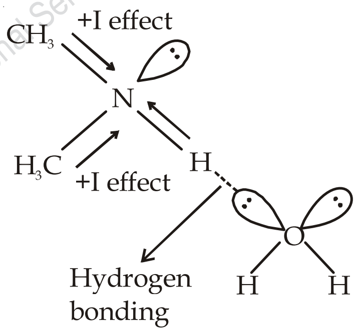
(4) $(CH_3)_3N$

Answer (2)

Sol. Among $C_6H_5NH_2$, CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N \cdot C_6H_5NH_2$ is least basic due to resonance.



Out of $(CH_3)_3N$, CH_3NH_2, $(CH_3)_2NH$. $(CH_3)_2NH$ is most basic due to +I effect and hydrogen bonding in H_2O.



89. If Z is a compressibility factor, van der Waals equation at low pressure can be written as

(1) $Z = 1 + \frac{Pb}{RT}$

(2) $Z = 1 + \frac{RT}{Pb}$

(3) $Z = 1 - \frac{a}{VRT}$

(4) $Z = 1 - \frac{Pb}{RT}$

Answer (3)

Sol. Compressibility factor $(Z) = \frac{PV}{RT}$

(For one mole of real gas)

van der Waal equation

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

At low pressure

$$V - b \approx V$$

$$\left(P + \frac{a}{V^2}\right)V = RT$$

$$PV + \frac{a}{V} = RT$$

$$PV = RT - \frac{a}{V}$$

$$\frac{PV}{RT} = 1 - \frac{a}{VRT}$$

So, $\boxed{Z = 1 - \frac{a}{VRT}}$

90. Which series of reactions correctly represents chemical reactions related to iron and its compound?

(1) $Fe \xrightarrow{O_2, heat} Fe_3O_4 \xrightarrow{CO, 600°C} FeO \xrightarrow{CO, 700°C} Fe$

(2) $Fe \xrightarrow{dil. H_2SO_4} FeSO_4 \xrightarrow{H_2SO_4, O_2} Fe_2(SO_4)_3 \xrightarrow{heat} Fe$

(3) $Fe \xrightarrow{O_2, heat} FeO \xrightarrow{dil. H_2SO_4} FeSO_4 \xrightarrow{heat} Fe$

(4) $Fe \xrightarrow{Cl_2, heat} FeCl_3 \xrightarrow{heat, air} FeCl_2 \xrightarrow{Zn} Fe$

Answer (4)

Sol. Anhydrous ferric chloride is prepared by passing dry chlorine gas over heated iron fillings.

$2Fe + 3Cl_2 \longrightarrow 2FeCl_3$

$FeCl_3$ on heating gives $FeCl_2$ and Cl_2

$FeCl_3 \xrightarrow{\Delta} 2FeCl_2 + Cl_2$

$FeCl_3$ is reduced by Zn form Fe and $ZnCl_2$

$FeCl_2 + Zn \longrightarrow Fe + ZnCl_2$

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