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21/01/2026
MORNING

Memory Based
Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

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

(Mathematics and Physics, Chemistry)

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.

SECTION-A

1. If α & β are roots of the quadratic equation $x^2 + x + 1 = 0$, then the value of $(\alpha + \beta)^4 + (\alpha^2 + \beta^2)^4 + (\alpha^3 + \beta^3)^4 + \ldots\ldots + (\alpha^{25} + \beta^{25})^4$ is -

(1) 145 (2) 140

(3) 415 (4) 541

Ans. **(1)**

Sol. $x^2 + x + 1 = 0$

$\Rightarrow x = \omega$ or ω^2

$\therefore \alpha = \omega$ & $\beta = \omega^2$

Now, $(\alpha + \beta)^4 + (\alpha^2 + \beta^2)^4 + (\alpha^3 + \beta^3)^4 + \ldots + (\alpha^{25} + \beta^{25})^4$

$=(\omega + \omega^2)^4 + (\omega^2 + \omega^4)^4 + (\omega^3 + \omega^6)^4 + \ldots + (\omega^{25} + \omega^{50})^4$

$=[(\omega + \omega^2)^4 + (\omega^2 + \omega^4)^4 + (\omega^4 + \omega^8)^4 + \ldots + (\omega^{25} + \omega^{50})^4] + [(\omega^3 + \omega^6)^4 + (\omega^6 + \omega^{12})^4 + (\omega^9 + \omega^{18})^4 + \ldots + (\omega^{24} + \omega^{48})^4]$

$= \underbrace{[1+1+1+.....+1]}_{17\,\text{times}} + \underbrace{[(1+1)^4+(1+1)^4+.....(1+1)^4]}_{8\,\text{times}}$

$= 17 + 128$

$= 145$

2. If $A = \begin{bmatrix} \alpha & 2 \\ 1 & 2 \end{bmatrix}$ and $B = A = \begin{bmatrix} 1 & 1 \\ 1 & \beta \end{bmatrix}$ and $A^2 - 4A + 2I = \mathbf{O}$ and $B^2 = 3B + I = \mathbf{O}$ then the value of $\left|\text{adj}\,(A^3 - B^3)\right|$ is

(1) – 5 (2) –15

(3) 9 (4) –7

Ans. **(2)**

Sol. $\text{Tr}(A) = 4 \Rightarrow \alpha + 2 = 4 \Rightarrow \alpha = 2$

$\text{Tr}(B) = 3 \Rightarrow \beta + 1 = 3 \Rightarrow \beta = 2$

$A^2 - 4A + 2I = \mathbf{O}$

$\Rightarrow A^2 = 4A - 2I$

$A^3 = 4A^2 - 2A = 16A - 8I - 2A$

$= 14A - 8I$

$= \begin{bmatrix} 28 & 28 \\ 14 & 28 \end{bmatrix} + \begin{bmatrix} -8 & 0 \\ 0 & -8 \end{bmatrix}$

$= A^3 = \begin{bmatrix} 20 & 28 \\ 14 & 20 \end{bmatrix}$

$B^2 - 3B + I = \mathbf{O}$

$B^2 = 3B - I \Rightarrow B^3 = 3B^2 - B = 3(3B - I) - B = 8B - 3I$

$B^3 = \begin{pmatrix} 8 & 8 \\ 8 & 16 \end{pmatrix} + \begin{pmatrix} -3 & 0 \\ 0 & -3 \end{pmatrix} = \begin{pmatrix} 5 & 8 \\ 8 & 13 \end{pmatrix}$

$A^3 - B^3 = \begin{pmatrix} 20 & 28 \\ 14 & 20 \end{pmatrix} - \begin{pmatrix} 5 & 8 \\ 8 & 13 \end{pmatrix} = \begin{pmatrix} 15 & 20 \\ 6 & 7 \end{pmatrix}$

$\Rightarrow \left|A^3 - B^3\right| = 105 - 120 = -15$

$\Rightarrow \left|\text{adj}\,(A^3 - B^3)\right| = \left|A^3 - B^3\right| = -15$

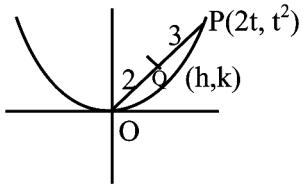
3. Let the parabola $x^2 = 4y$ and consider its vertex O and a variable point P on the parabola and consider another point Q which divides OP is the ratio 2 : 3 internally. Then the equation of chord of locus Q whose mid point is (1, 2):

(1) $5x - 4y + 3 = 0$ (2) $4x - 5y + 3 = 0$

(3) $5x + 4y + 3 = 0$ (4) $4x + 5y + 3 = 0$

Ans. **(1)**

Sol. $h = \dfrac{4t}{5}$



$k = \dfrac{2t^2}{5} = \dfrac{2}{5}.\left(\dfrac{5h}{4}\right)^2$

$8k = 5h^2$

$\Rightarrow 5x^2 = 8y$

$T = S_1$

$5(xx_1) - 4(y + y_1) = 5x_1^2 - 8y_1$

$5(x) - 4(y + 2) = 5 - 8.2$

$5x - 4y + 3 = 0$

4. Let $f : R \to R$ be twice differentiable function such that $f(x)m^2 - 2m.f'(x) + f''(x) = 0$ for all $m \in R$ has equal roots where $f(0) = 1$, $f'(0) = 2$ and $f(\ln x - x)$ is increasing in the interval $(\alpha,\beta]$, then find $(\alpha + \beta)$.

(1) 1 (2) 2

(3) 3 (4) 4

Ans. (1)

Sol. Given quadratic equation has equal roots, thus

$D = 0 \Rightarrow (f'(x))^2 = f''(x) \cdot f(x)$

$$\frac{f'(x)}{f(x)} = \frac{f''(x)}{f'(x)}$$

Integrate

$\ln (f(x)) = \ln (f'(x)) + \ln C \Rightarrow f(x) = c.f'(x)$

Put $= x = 0$

$$1 = c.2 \Rightarrow c = \frac{1}{2}$$

Now $2f(x) = f'(x)$

$$\Rightarrow \frac{f'(x)}{f(x)} = 2$$

Integrate

$\ln (f(x)) = 2x + d$

Put $x = 0$

$\Rightarrow d = 0$

$\Rightarrow \ln (f(x)) = 2x \Rightarrow f(x) = e^{2x}$

Now Let $g(x) = f(\ln x - x) = e^{2(\ln x - x)}$

$$\therefore g'(x) = e^{2(\ln x - x)}\left(\frac{1}{x} - 1\right) \geq 0$$

$$\Rightarrow \frac{1-x}{x} \geq 0$$

$\Rightarrow x \in (0, 1]$

$\Rightarrow \alpha = 0, \beta = 1$

$\alpha + \beta = 1.$

5. Given two set $A = \{1, 2, 3, \ldots\ldots, 6\}$ and $B = \{1, 2, 3, \ldots\ldots, 9\}$, the find the number of increasing funcitons $f : A \to B$, such that $f(i) \neq i \ \forall i \in \{1, 2, 3, \ldots\ldots, 6\}$:

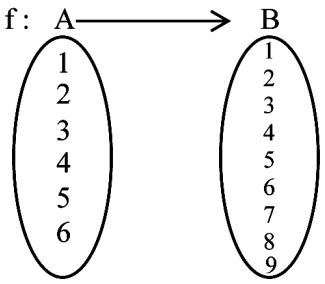
(1) 26 (2) 27

(3) 28 (4) 29

Ans. (3)

Sol. $f(i) \neq i$, $f(x)$ is strictly increasing function $f : A \to B$, where A $\{1, 2,3 \ldots\ldots 6\}$

B $\{1, 2, 3, \ldots..9\}$, then number of function $f : A \to B$ is equal to .



$f(i) \neq i$ Case-i $f(1) = 2 \Rightarrow {}^7C_5 = 21$

Case-ii $f(1) = 3 \Rightarrow {}^6C_5 = 6$

Case-iii $f(1) = 4 \Rightarrow {}^5C_5 = 1$

No of function A to B $= 21 + 6 + 1 = 28$

6. Tangent are drawn from P to the circle $x^2 + y^2 - 4x - 6y + 12 = 0$ touching at A & B such that $\angle AOB = 60°$ (0 is centre of circle) then locus of P is :

(1) $x^2 + y^2 - 4x - 6y + \frac{35}{3} = 0$

(2) $x^2 + y^2 - 6x - 4y + \frac{35}{3} = 0$

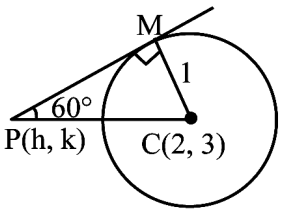
(3) $x^2 + y^2 - 4x - 6y + 35 = 0$

(4) $x^2 + y^2 - 4x - 6y + 40 = 0$

Ans. (1)

Sol. $\tan 60° = \sqrt{3} = \frac{OM}{PM}$

$$\therefore PM = \frac{1}{\sqrt{3}}$$



& equation to circle is

$S \equiv x^2 + y^2 - 4x - 6y + 12 = 0$

$\therefore$ $PM = \sqrt{S(h,k)} = \frac{1}{\sqrt{3}}$

$\therefore$ locus to P(h, k) is

$$x^2 + y^2 - 4x - 6y + 12 = \frac{1}{3}$$

i.e $x^2 + y^2 - 4x - 6y + \frac{35}{3} = 0$

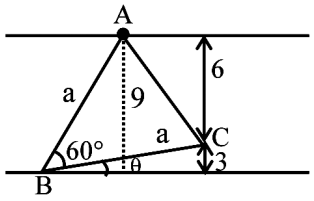
7. L_1 & L_2 are two parallel lines and ABC is an equilateral triangle , such that A & B lie on L_1 & L_2 respectively. Vertex C is at a distance of 6 unit from L_1 & 3 unit from L_2. Then Area ΔABC is :

(1) $21\frac{\sqrt{3}}{3}$ (2) $21\sqrt{3}$

(3) $23\frac{\sqrt{3}}{3}$ (4) $23\sqrt{3}$

Ans. (2)

Sol.



$$\sin\theta = \frac{3}{a}$$

$$\sin(60° + \theta) = \frac{9}{a}$$

$$\frac{\sqrt{3}}{2}\cos\theta + \frac{1}{2}\sin\theta = \frac{9}{a}$$

$$\sqrt{3}\sqrt{1 - \frac{9}{a^2}} + \frac{3}{a} = \frac{18}{a}$$

$$a = \sqrt{84}$$

Area of $\Delta ABC = \frac{\sqrt{3}}{4}a^2$

$$= \frac{\sqrt{3}}{4} \times 84$$

$$= 21\sqrt{3}$$

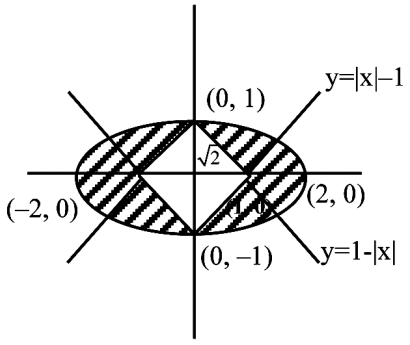
8. Area bounded inside ellipse $x^2 + 4y^2 = 4$ and outside area bounded by curve $y = |x| - 1$ and $y = 1 - |x|$:

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

(3) $2\pi + 2$ (4) $2\pi - 2$

Ans. (4)

Sol. $\frac{x^2}{4} + \frac{y^2}{1} = 1$



to find Area of shaded portion

= Total Area – Area of square

$= \pi(2)(1) - \left(\sqrt{2}\right)\left(\sqrt{2}\right)$

$= 2\pi - 2$

9. If $y = y(x)$ and $(1 + x^2)\,dy + (1 - \tan^{-1}x)\,dx = 0$ and $y(0) = 1$ then $y(1)$ is :

(1) $\frac{\pi^2}{32} + \frac{\pi}{4} + 1$ (2) $\frac{\pi^2}{32} - \frac{\pi}{4} + 1$

(3) $\frac{\pi^2}{32} - \frac{\pi}{2} - 1$ (4) $\frac{\pi^2}{32} - \frac{\pi}{2} + 1$

Ans. (2)

Sol. $(1 + x^2)dy + (1 - \tan^{-1}x)\,dx = 0$

$$\Rightarrow \int dy + \int \frac{1 - \tan^{-1}(x)}{1 + x^2}dx = 0$$

$$\left\{\text{put } \begin{matrix} 1 - \tan^{-1}x = t \\ \Rightarrow \frac{dx}{1 + x^2} = -dt \end{matrix}\right\}$$

$$\Rightarrow y - \int t\,dt = 0$$

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

$$\left\{\text{put } \begin{matrix} x = 0 \ \& \ y = 1 \\ \therefore 1 = \frac{1}{2} + c \Rightarrow c = \frac{1}{2} \end{matrix}\right\}$$

Now $\boxed{y = \frac{\left(1 - \tan^{-1}(x)\right)^2 + 1}{2}}$

Find $y(1) - \frac{\left(1 - \frac{\pi}{4}\right)^2 + 1}{2} = \frac{\pi^2}{32} - \frac{\pi}{4} + 1$

10. The value of $\text{cosec}10° - \sqrt{3}\sec 10°$ is :

(1) 1 (2) 2

(3) 3 (4) 4

Ans. (4)

Sol. $= \dfrac{1}{\sin 10°} - \dfrac{\sqrt{3}}{\cos 10°}$

$= \dfrac{\cos 10° - \sqrt{3}\sin 10°}{\sin 10°\ \cos 10°}$

$= 4.\left[\dfrac{\frac{1}{2}\cos 10° - \frac{\sqrt{3}}{2}\sin 10°}{2\sin 10°\cos 10°}\right]$

$= 4.\left[\dfrac{\sin(30° - 10°)}{\sin 20°}\right]$

$= 4$

11. Let H be a Hyperbola confocal with ellipse $\dfrac{x^2}{36} + \dfrac{y^2}{16} = 1$ having eccentricity '5', then length of latus rectum of H is :

(1) $\dfrac{96}{\sqrt{5}}$ (2) $\dfrac{9}{\sqrt{5}}$

(3) 96 (4) $\sqrt{5}$

Ans. (1)

Sol. Let e_1 be eccentricity of ellipse

$\Rightarrow e_1 = \sqrt{1 - \dfrac{16}{36}} = \sqrt{1 - \dfrac{4}{9}} = \dfrac{\sqrt{5}}{3}$

So $ae_1 = 6.\dfrac{\sqrt{5}}{3} = 2\sqrt{5}$

Now H : $\dfrac{x^2}{p^2} - \dfrac{y^2}{q^2} = 1$

$p.e = ae_1$

$p.5 = 2\sqrt{5}$

$p = \dfrac{2}{\sqrt{5}} \Rightarrow e^2 = 1 + \dfrac{q^2}{p^2} \Rightarrow 25 = 1 + \dfrac{5q^2}{4} \Rightarrow q^2 = \dfrac{96}{5}$

So length of LR $\dfrac{2q^2}{p} = \dfrac{96}{\sqrt{5}}$

12. The value of integral $I = \displaystyle\int_{-\pi/6}^{\pi/6} \frac{2\pi + 4x^{11}}{1 - \sin(|x| + \pi/6)}dx$ is

(1) π (2) 2π

(3) 4π (4) 8π

Ans. (4)

Sol. $= 4\pi\displaystyle\int_0^{\pi/6} \frac{1}{1 - \sin\left(x + \frac{\pi}{6}\right)}dx$ let $x + \dfrac{\pi}{6} = t$ $dx = dt$

$= 4\pi\displaystyle\int_{\pi/6}^{\pi/3} \frac{dt}{1 - \sin t} = 4\pi\int_{\pi/6}^{\pi/3} \frac{1 + \sin t}{\cos^2 t}dt$

$= 4\pi\left[\displaystyle\int_{\pi/6}^{\pi/3} \sec^2 t\,dt + \int_{\pi/6}^{\pi/3} \sec t \tan t\,dt\right]$

$= 4\pi\left[(\tan t)_{\pi/6}^{\pi/3} + (\sec t)_{\pi/6}^{\pi/3}\right]$

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

$= 4\pi\left[\sqrt{3} + 2 - \sqrt{3}\right] = 8\pi$

13. If the mean and variance of observations x, y, 12, 14, 4, 10, 2 is 8 and 16 respectively where $x > y$. Then, the value of $3x - y$ is

(1) 18 (2) 20

(3) 22 (4) 24

Answer (1)

Sol. $\dfrac{x + y + 12 + 14 + 4 + 10 + 2}{7} = 8$

$\Rightarrow x + y = 14$

also var = 16

$\dfrac{x^2 + y^2 + 144 + 196 + 16 + 100 + 4}{7} - (8)^2 = 16$

$\Rightarrow x^2 + y^2 = 100$

By solving we get

$x = 8$, $y = 6$

$\Rightarrow 3x - y = 18$

SECTION-B

14. Consider the expansion $(ax^2 + bx + c)(1 - 2x)^{26}$. If the coefficient of x^2 and x^3 are zero and coefficient of x is – 56 then (a + b + c) is

Ans. (1403)

Sol. $(ax^2 + bc + c)\displaystyle\sum_{r=0}^{26} {}^{26}C_r(-2x)^r$

Coeff. of x^2 : $a.{}^{26}C_0\ (-2)^0 + b.{}^{26}C_1(-2) + c.{}^{26}C_2(-2)^2 = 0$

$\Rightarrow a - 52b + 1300c = 0$ … (1)

Coeff. of x^3 : $a.{}^{26}C_1\ (-2) + b.{}^{26}C_2(-2)^2 + c.{}^{26}C_3(-2)^3 = 0$

$\Rightarrow -52a + 1300b - 20800c = 0$ … (2)

Coeff. of $x = -56$

$\Rightarrow b.{}^{26}C_0\ (-2)^0 + c.{}^{26}C_1(-2)^1 = -56$

$b - 52c = -56$ … (3)

After solving (1), (2) & (3)

$a = 1300$, $b = 100$, $c = 3$

$\Rightarrow a + b + c = 1403$

15. Sum of roots of equation $|x-1|^2-5|x-1|+6=0$ is

Ans. (4)

Sol. Let $|x-1|=t$

$t^2-5x+6=0$

$t=2$ & $t=3$

$|x-1|=2$ & $|x-1|=3$

$x-1=\pm 2$ & $x-1=\pm 3$

$x=1\pm 2$ & $x=1\pm 3$

$\therefore$ root $=3,-1,4,-2$

$\therefore$ Sum of root $=3+(-1)+4+(-2)=4$.

16. If Domain of

$f(x)=\cos^{-1}\left(\frac{2x-5}{11-3x}\right)+\sin^{-1}(2x^2-3x+1)$ is [a, b],

find value of (a + 2b):

Sol. $-1\le\frac{2x-5}{11-3x}\le 1$ & $-1\le 2x^2-3x+1\le 1$

$\Rightarrow \frac{2x-5}{11-3x}-1\le 0$, $\frac{2x-5}{11-3x}+1\ge 0$, $2x^2-3x\le 0$

$\frac{2x-5-11+3x}{11-3x}\le 0$, $\frac{-x+6}{11-3x}\ge 0$, $2x^2-3x\le 0$

$\frac{5x-16}{11-3x}\le 0$ & $\frac{x-6}{3x-11}\ge 0$ & $2x^2-3x\le 0$

$x\le\frac{16}{5}$ or $\frac{11}{3}<x$ & $x<\frac{11}{3}$ or $6\le x$ & $0\le x\le\frac{3}{2}$

taking intersection

$\Rightarrow x\in\left[0,\frac{3}{2}\right] \Rightarrow a=0, b=\frac{3}{2}$

$\Rightarrow a+2b=0+2\left(\frac{3}{2}\right)$

$=3$

17. Given

$a_{n+1}-\frac{1}{2}a_n=\frac{n^2-2n-1}{n^2(n+1)^2}, n\ge 1$ such that $a_1=1$ then

evaluate $\left|\sum_{n=1}^{\infty}\left(a_n-\frac{2}{n^2}\right)\right|$

Sol. $a_{n+1}-\frac{1}{2}a_n=\frac{n^2-2n-1}{n^2(n+1)^2}=\frac{2n^2-(n+1)^2}{n^2(n+1)^2}$

$\Rightarrow a_{n+1}-\frac{1}{2}a_n=\frac{2}{(n+1)^2}-\frac{1}{n^2}$

$n=1$ $a_2-\frac{1}{2}a_1=\frac{2}{2^2}-\frac{1}{12}$

$2\left[a_3-\frac{1}{2}a_2=\frac{2}{3^2}-\frac{1}{2^2}\right]$

$2^2\left[a_4-\frac{1}{2}a_3=\frac{2}{4^2}-\frac{1}{3^2}\right]$

$\vdots$

$2^{n-2}\left[a_n-\frac{1}{2}a_{n-1}=\frac{2}{n^2}-\frac{1}{(n-1)^2}\right]$

$2^{n-1}\left[a_{n+1}-\frac{1}{2}a_n=\frac{2}{(n+1)^2}-\frac{1}{n^2}\right]$

Adding

$a_{n+1}=\frac{2}{(n+1)^2}-\frac{1}{2^n}$ $\Rightarrow a_n=\frac{2}{n^2}-\frac{1}{2^{n-1}}$

$\Rightarrow\left|\sum_{n=1}^{\infty}\left(a_n-\frac{2}{n^2}\right)\right|=\left|\sum_{n=1}^{\infty}-\frac{1}{2^{n-1}}\right|=2$

18. If a_1, a_2, a_3…….are increasing geometric progression such that $a_1+a_3+a_5=21$ and $a_1a_3a_5=64$, then value of $a_1+a_2+a_3$ is

Ans. (7)

Sol. Let the G.P. a, ar, ar^2, ar^3……..

$a_1+a_3+a_5=21\Rightarrow a+ar^2+ar^4=21$ ….. (1)

$a_1.a_3.a_5=64\Rightarrow a.ar^2.ar^4=64\Rightarrow a^3r^6=64$ …. (2)

$ar^2=4$

$\frac{4}{r^2}+4+4r^2=21$

$\Rightarrow 4r^4-17r^2+4=0$

$r^2=4$ or $r^2=\frac{1}{4}$ (Reject)

$\boxed{r=2}$

$\Rightarrow\boxed{a=1}$

$a_1+a_2+a_3=a+ar+ar^2$

$=a(1+r+r^2)=1.(1+2+2^2)=7$

19. The value of $6\int_0^{\pi}|\sin x+\sin 3x+\sin 2x|dx$ is :

Ans. (17)

Sol. $6\int_0^{\pi}|2\sin 2x\cos x+\sin 2x|dx$

$6\int_0^{\pi}|4\sin x\cos^2 x+2\sin x\cos x|dx$

$$I = 12\int_0^{\pi} \sin x\left|2\cos^2 x + \cos x\right| dx$$

Put cosx = t, $-\sin x\, dx = dt$

$$I = -12\int_1^{-1}\left|2t^2 + t\right| dt = 12\int_{-1}^{1}\left|2t^2 + t\right| dt$$

$$I = 12\left(\int_{-1}^{-1/2}\left(2t^2 + t\right)dt + \int_{-1/2}^{0} -\left(2t^2 + t\right)dt + \int_0^1\left(2t^2 + t\right)dt\right.$$

I = 17

20. Let a twice differentiable function f(x) on R such that f(3) = 18, f'(3) = 0 and $f''(3) = 4$, then the value of $\log_e\left(\lim_{x\to 1}\left(\frac{f(x+2)}{f(3)}\right)^{\frac{18}{(x-1)^2}}\right)$ is :

Ans. (2)

Sol. Let $T = \lim_{x\to 1}\left(\frac{f(x+2)}{f(3)}\right)^{\frac{18}{(x-1)^2}}$; 1^{∞} form

$$\Rightarrow T = e^{\lim_{x\to 1}\frac{18}{(x-1)^2}\left(\frac{f(x+2)-f(3)}{f(3)}\right)}$$

$$\Rightarrow T = e^{\lim_{x\to 1}\frac{18}{(x-1)^2}\left(\frac{f(x+2)-f(3)}{18}\right)}$$

$$\Rightarrow T = e^{\lim_{x\to 1}\left(\frac{f(x+2)-f(3)}{(x-1)^2}\right),\ \frac{0}{0}\text{ form}} \quad \text{apply L'pital}$$

$$\Rightarrow T = e^{\lim_{x\to 1}\frac{f'(x+2)}{2(x-1)}\ ;\ \frac{0}{0}\text{ form}} \quad \text{apply L'pital}$$

$$\Rightarrow T = e^{\lim_{x\to 1}\frac{f''(x+2)}{2}\ ;\ = e^{\frac{4}{2}} = e^2}$$

$$\Rightarrow \log_e(T) = 2$$

21. Consider set $S = \{1,2,3,.....50\}$ where m, n, $\in$ S. If P is the no. of ways such that $6^m + 9^n$ is divisible by 5 and Q is the no. of ways in which (m + n) is the square of prime number. Find (P + Q)

Ans. (1333)

Sol. $S = \{1,2,3,.....50\}$

$P = (6^m + 9^n)$ is divisible by 5

No. of ways

$6^m = (5\lambda + 1)^m = 5k + 1$

$9^n = (10-1)^n = 10\mu - 1$ if n is odd $\Rightarrow$ n must be odd

$10\mu + 1$ if n is even

$\Rightarrow$ No. of ways = 50 × 25 = 1250

$Q \Rightarrow (m + n)$ is square of a prime

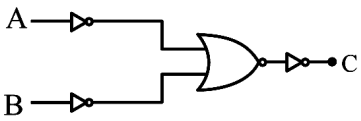
	$m+n=4$	$m+n=9$	$m+n=25$	$m+n=49$
No. of ways	↓ 3 ,	↓ 8 ,	↓ 24 ,	↓ 48 ,

Q = 3 + 8 + 24 + 48 = 83

= P + Q = 1250 + 83 = 1333

SECTION-A

1. Which logic gate is given in the figure?



(1) XOR (2) NOR

(3) NAND (4) OR

Ans. **(3)**

Sol.

A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

(NAND)

2. Given energy density equation for unsteady flow

$$\left(P+\frac{A}{Bt^2}\right)+\frac{1}{2}\rho v^2+\rho g(h+Bt)$$

Find dimension of A and B.

(1) $[A] = MT^{-1}$, $[B] = LT^{-1}$

(2) $[A] = MT^{-2}$, $[B] = LT^{-1}$

(3) $[A] = MT^{-1}$, $[B] = LT^{-2}$

(4) $[A] = M^2T^{-1}$, $[B] = LT^{-1}$

Ans. **(1)**

Sol. $[h] = [B][t]$

$[L] = [B][T]$

$[B] = [L][T]^{-1}$

$[B] = LT^{-1}$ unit : m/s

$$[P] = \left[\frac{A}{Bt^2}\right]$$

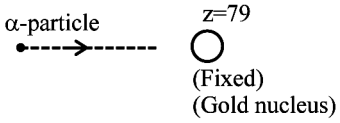
$$[ML^{-1}T^{-2}] = \frac{[A]}{[LT^{-1}][T^2]}$$

$[A] = [ML^{-1}T^{-2}]\,[LT^{-1}]\,[T^2]$

$= [MT^{-1}]$

$[A] = MT^{-1}$ unit Kg/s

3. An α-particle is projected from infinity towards a fixed gold nucleus with energy 7.7 MeV. Find minimum distance between α-particle and gold nucleus:



(1) 0.4×10^{-13} m (2) 0.3×10^{-13} m

(3) 0.5×10^{-13} m (4) 0.7×10^{-13} m

Ans. **(2)**

Sol. Energy conservation

$K_i + U_i = K_f + U_f$

$7.7 \times 10^6 \times 1.6 \times 10^{-19} + 0$

$$= 0 + \frac{9\times10^9\times2\times(1.6\times10^{-19})\times79\times1.6\times10^{-19}}{r}$$

$7.7 \times 10^6 \times 1.6 \times 10^{-19}$

$$= \frac{9\times10^9\times2\times(1.6\times10^{-19})\times79\times(1.6\times10^{-19})}{r}$$

$$r = \frac{9\times10^9\times2\times1.6\times10^{-19}\times79}{7.7\times10^6}$$

$= 295.5 \times 10^{-16}$

$= 0.2955 \times 10^{-13}$

$= 0.3 \times 10^{-13}$ m

4. From a ring of area 1 m^2 and resistance 100 Ω, a magnetic field B = sin (100t) T is passing perpendicular to the ring. Find heat produce in one time period in joule :

(1) 4π (2) 3π (3) 2π (4) π

Ans. **(4)**

Sol. $\phi = NAB = (1)\,(1)\,[\sin(100t)]$

$\phi = \sin(100t)$

$e = -\dfrac{d\phi}{dt} = -\dfrac{d}{dt}[\sin(100t)] = -100\cos(100t)$

$e = -100\cos(100t)$ volt

current : $i = \dfrac{E}{R} = \dfrac{-100\cos(100t)}{100} = -\cos(100t)$

Heat : $\int i^2 R dt = \int [\cos^2(100t)]100dt$

$= 100\int_0^T \cos^2(100t)dt$

For 1 time period : $< \cos^2(100t) > = \dfrac{1}{2}$

$= 100 \times \dfrac{T}{2} = 50T = 50\left(\dfrac{2\pi}{\omega}\right) = \pi$

5. A charge $q_1 = 10^{-6}$C is at (0, 0, 0). Another charge $q_2 = 2\mu$C is taken from A (4, 4, 2) to B(2, 2, 1).

Find work done by external :

(1) 3×10^{-7} J (2) 2×10^{-7} J

(3) 3×10^{-5} J (4) 4×10^{-7} J

Ans. (1)

Sol. $V_A = \dfrac{Kq_1}{r_A} = \dfrac{K \times 10^{-10}}{\sqrt{16+16+4}}$

$= \dfrac{9\times10^9\times10^{-10}}{6} = \dfrac{3}{2}\times10^{-1}$ Volt

$V_B = \dfrac{Kq_1}{r_B} = \dfrac{9\times10^9\times10^{-10}}{3} = 3 \times 10^{-1}$ Volt

$W = q_2(V_B - V_A) = 2 \times 10^{-6}\,(3 - 1.5) \times 10^{-1}$

$W = 3 \times 10^{-7}$ Joule

6. An electromagnetic wave has electric filed component

$E_z = (63\ V/m)\sin(\omega t - kx)$

The corresponding magnetic field component should be :

(1) $B_y = -2.1 \times 10^{-7}\sin(\omega t - kx)$

(2) $B_y = 2.1 \times 10^{-7}\sin(\omega t + kx)$

(3) $B_z = 63\sin(\omega t - kx)$

(4) $B_z = 2.1 \times 10^{-7}\sin(\omega t + kx)$

Ans. (1)

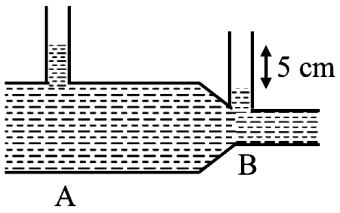
Sol. $E \to \hat{k}, C \to \hat{i}$

$\hat{C} \times \hat{E} = \hat{B} = -\hat{j}$

$B_0 = \dfrac{E_0}{C} = \dfrac{63}{3\times10^8} = 2.1 \times 10^{-7}$

$B_y = -(2.1 \times 10^{-7})\sin(\omega t - kx)$

7.



As shown in the figure find volume flow rate at cross section-B. Given area at A is 6 cm^2 and at B is 3 cm^2 :

(1) $2\sqrt{2}$ m^3/s (2) $2\sqrt{3}$ m^3/s

(3) $3\sqrt{2}$ m^3/s (4) $3\sqrt{3}$ m^3/s

Ans. (2)

Sol. $\rho gh = \dfrac{1}{2}\rho\left(v_B^2 - v_A^2\right)$

$v_B = 2v_A$

$\rho gh = \dfrac{1}{2}\rho\left(3v_A^2\right)$

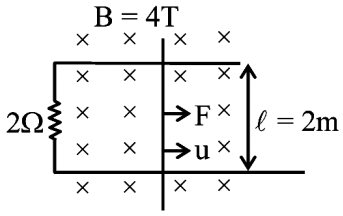
$v_A = \sqrt{\dfrac{2gh}{3}}$

vol-flow rate : $(6)\sqrt{\dfrac{2gh}{3}}$

$\Rightarrow \sqrt{\dfrac{2gh\times36}{3}} = \sqrt{\dfrac{2\times10\times5\times36}{100\times3}}$

Vol. flow rate = $2\sqrt{3}$ m^3/s

8. As shown in the figure find force required to move rod with constant velocity 15 m/s in uniform magnetic field :



(1) 480 N (2) 500 N

(3) 380 N (4) 280 N

Ans. (1)

Sol. Induced emf $e = Bv\ell = 4 \times 15 \times 2 = 120$ v

$$I = \frac{e}{R} = 60A$$

$$F = i\ell B = 60 \times 2 \times 4 = 480 \text{ N}$$

9. A gas based geyser heat water at rate of 5 litres per minute from 27° to 87°C. If the rate of consumption of energy by gas geyser is $x \times 10^4$ W. Find value of 'x' :

(1) 2.1 (2) 0.2

(3) 4.2 (4) 0.42

Ans. (1)

Sol. Rate of water flow $= \frac{(5)(1)}{60}\text{Kg/s} = \frac{1}{12}\text{Kg/s}$

Power $= mS_w(\Delta T)$

$$= \frac{1}{12} \times (4200)(87-27)$$

$= 21$ KW

10. Given acceleration as a function of time $\vec{a} = t^3\hat{i} - \frac{3t}{4}\hat{j}$. Initially (t = 0) position is $0\hat{i} + 0\hat{j} + 0\hat{k}$ and particle is at rest find position and velocity at any instant:

(1) $\vec{v} = \frac{t^4}{4}\hat{i} - \frac{3t^2}{8}\hat{j}$, $\vec{r} = +\frac{t^5}{20}\hat{i} - \frac{t^3}{8}\hat{j}$

(2) $\vec{v} = \frac{t^3}{4}\hat{i} - \frac{3t^3}{8}\hat{j}$, $\vec{r} = +\frac{t^5}{20}\hat{i} - \frac{t^3}{8}\hat{j}$

(3) $\vec{v} = \frac{t^4}{4}\hat{i} - \frac{3t^2}{8}\hat{j}$, $\vec{r} = +\frac{t^6}{20}\hat{i} - \frac{t^2}{8}\hat{j}$

(4) $\vec{v} = \frac{t^4}{2}\hat{i} - \frac{t^2}{3}\hat{j}$, $\vec{r} = +\frac{t^5}{20}\hat{i} - \frac{t^3}{8}\hat{j}$

Ans. (1)

Sol. $\vec{a} = t^3\hat{i} - \frac{3t}{4}\hat{j}$

$$\frac{d\vec{v}}{dt} = t^3\hat{i} - \frac{3t}{4}\hat{j}$$

$$\vec{v} = \int_0^t \left(t^3\hat{i} - \frac{3t}{4}\hat{j}\right)dt$$

$$\vec{v} = \frac{t^4}{4}\hat{i} - \frac{3t^2}{8}\hat{j}$$

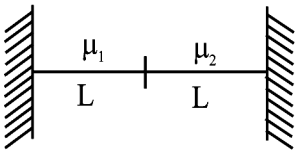
$$\frac{d\vec{r}}{dt} = \frac{t^4}{4}\hat{i} - \frac{3t^2}{8}\hat{j}$$

$$\vec{r} = \int d\vec{r} = \int \left(\frac{t^4}{4}\hat{i} - \frac{3t^2}{8}\hat{j}\right)dt$$

$$\vec{r} = +\frac{t^5}{20}\hat{i} - \frac{3t^3}{24}\hat{j}$$

$$\vec{r} = +\frac{t^5}{20}\hat{i} - \frac{t^3}{8}\hat{j}$$

11. In the diagram shown time taken by a pulse to travel on string 1 is t_1 while on string 2 is t_2. Find $\frac{t_1}{t_2}$.



Given $\mu_1 = 2 \times 10^{-4}$ kg/m , $\mu_2 = 4 \times 10^{-4}$ kg/m

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

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

Ans. (1)

Sol. $t_1 = \frac{L}{v_1}, t_2 = \frac{L}{v_2}$

$$v_1 = \sqrt{\frac{T}{\mu_1}} = \sqrt{\frac{500}{2\times10^{-4}}}$$

$$v_1 = 10^2 \times 10\sqrt{\frac{5}{2}}$$

$$v_2 = \sqrt{\frac{T}{\mu_2}} = \sqrt{\frac{500}{4\times10^{-4}}}$$

$$v_2 = 10^2 \times 10\sqrt{\frac{5/4}{4}}$$

$$\frac{t_1}{t_2} = \frac{v_2}{v_1} = \frac{\sqrt{5/4}}{\sqrt{5/2}} = \sqrt{\frac{2}{4}} = \frac{1}{\sqrt{2}}$$ Ans.

12. A light wave described by E = 60 (sin (3×10^{15})t + sin (12×10^{15})t) (in SI unit) fall on a metal surface of work function 2.8 eV. The maximum kinetic energy of ejected photon is approximate (in eV)

(Given : h = 6.6×10^{-34} J-S)

(1) 5.1 eV (2) 6.1 eV

(3) 4.1 eV (4) 3.1 eV

Ans. (1)

Sol. $\omega_1 = 3 \times 10^{15}$ rad/s

$\omega_2 = 12 \times 10^{15}$ rad/s

$\phi = 2.8$ eV

$$v = \frac{\omega}{2\pi}$$

$$v_{max} = \frac{12\times10^{15}}{2\pi} \simeq 1.91 \times 10^{15} \text{ Hz}$$

$E_{photon} = h\nu = 6.6 \times 10^{-34} \times 1.91 \times 10^{15}$

$= 1.26 \times 10^{-18}$ J

$$E_{max} = \frac{1.26\times10^{-18}}{1.6\times10^{-19}} \simeq 7.9\text{eV}$$

$k_{max} = E_{max} - \phi = 7.9 - 2.8$

$k_{max} = 5.1$ eV

13. Two equal rods are joined to form a single rod of 120 cm. Find final rod length when temperature is raised from 30°C to 100°C. Given :

$\alpha_A = 1.2 \times 10^{-5}$/°C

$\alpha_B = 24 \times 10^{-6}$/°C

(1) 121.15 cm

(2) 122.15 cm

(3) 120.15 cm

(4) 119.15 cm

Ans. (3)

Sol. $\ell_{final} = \ell_0 (1 + \alpha_A \Delta T) + \ell_0 (1 + \alpha_B \Delta T)$

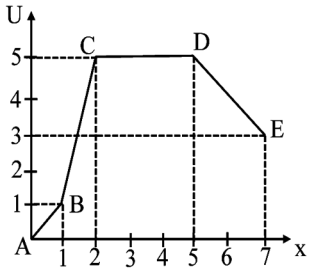
$= 60 (2 + (\alpha_A + \alpha_B)\Delta T)$

$= 60 (2 + (12 \times 10^{-6} + 24 \times 10^{-6})70)$

$= 60 (2 + 0.0025)$

final = 120.15 cm

14. A graph of potential energy as position is given below. Give the order of magnitude of forces.



(1) $|F_{CD}| < |F_{AB}| = |F_{DE}| < |F_{BC}|$

(2) $|F_{CD}| < |F_{AB}| > |F_{DE}| < |F_{BC}|$

(3) $|F_{CD}| < |F_{AB}| < |F_{DE}| < |F_{BC}|$

(4) $|F_{CD}| = |F_{AB}| = |F_{DE}| < |F_{BC}|$

Ans. (1)

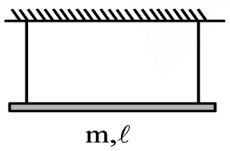
Sol. $$|F_{AB}| = \left|\frac{-dU}{dx}\right| = \frac{1-0}{1-0} = 1$$

$$|F_{BC}| = \left|\frac{-dU}{dx}\right| = \frac{5-1}{2-1} = 4$$

$$|F_{CD}| = \left|\frac{-dU}{dx}\right| = 0$$

$$|F_{DE}| = \left|\frac{-dU}{dx}\right| = \left|\frac{3-5}{7-5}\right| = 1$$

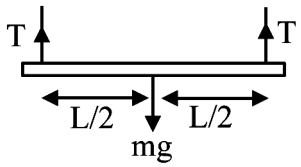
15. A rod of mass m and length ℓ is attached to two ideal strings. Find tension in left string just after right of string is cut.



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

Ans. (2)

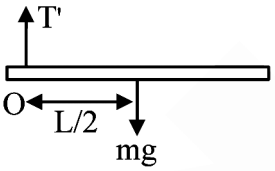
Sol. **Before**



$2T = mg$

$$T = \frac{mg}{2}$$

After :



$$mg\frac{L}{2} = I_0\alpha$$

$$mg\frac{L}{2} = \frac{mL^2}{3}\alpha$$

$$\frac{3}{2}\frac{g}{L} = \alpha$$

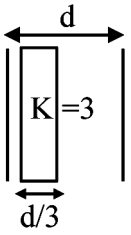
$mg - T' = ma_t$

$$T' = mg - m\left(\alpha\frac{L}{2}\right)$$

$$T' = mg - m\left(\frac{3g}{4}\right)$$

$$T' = \frac{mg}{4}$$

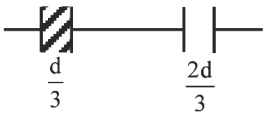
16. A capacitor of capacitance 'C' is given. Find the capacitance after dielectric is inserted as shown.



(1) $\frac{9}{7}C$ (2) $\frac{3}{7}C$ (3) $\frac{6}{7}C$ (4) $\frac{5}{7}C$

Ans. **(2)**

Sol.



$$C_1 = \frac{3A\in_0 k}{d}, C_2 = \frac{3A\in_0}{2d}$$

$$\frac{1}{C'} = \frac{d}{3A\in_0 k} + \frac{2d}{3A\in_0}$$

$$= \frac{d}{3A\in_0}\left(\frac{1}{k} + 2\right)$$

$$C' = \frac{3A\in_0 k}{(1+2k)d} = \frac{3k}{1+2k}.C$$

$k = 3$

$$C' = \frac{9}{7}C$$

17. A magnet is dropped inside a coil as shown in figure. Its acceleration as it falls through the coil is 'a'. Choose the correct option.

(1) $a = g$ (2) $a > g$

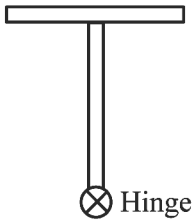
(3) $a < g$ (4) $a = 0$

Ans. **(3)**

Sol. The coil will oppose the motion of magnet due to induced current as result of change in magnetic flux.

$\therefore a < g$

18. Two rods are joined together as shown. If moment of inertia about Hinge is $\frac{x}{12}m\ell^2$. Find x. (Both rods have mass m and length ℓ)



(1) 10 (2) 12

(3) 13 (4) 17

Ans. (4)

Sol. $I_{hinge} = I_1 + I_2$

$$= \frac{m\ell^2}{3} + \left(\frac{m\ell^2}{12} + m(\ell)^2\right)$$

$$= \frac{m\ell^2}{3} + \frac{13m\ell^2}{12}$$

$$= \frac{4m\ell^2 + 13m\ell^2}{12}$$

$$I = \frac{17}{12}m\ell^2$$

$$\frac{x}{12}m\ell^2 = \frac{17}{12}m\ell^2$$

x = 17

19. Find energy required for a satellite to go from r = 1.5 R_E to r = $3R_E$. (Given : Mass of satellite is 100 kg. Radius of Earth $R_E = 6 \times 10^6$ m and acceleration due to gravity g = 10 m/s^2).

(1) 10^9 J

(2) 10^{11} J

(3) 10^{10} J

(4) 10^8 J

Ans. (1)

Sol. $E = \frac{-GMm}{2r}$ $\qquad r_1 = 1.5R_E = \frac{3}{2}R_E$

$E_1 = \frac{-GMm}{2r_1}$ $\qquad r_2 = 3R_E$

$E_2 = -\frac{GMm}{2r_2}$

$$E_1 = \frac{-GMm}{2\left(\frac{3}{2}R_E\right)} = \frac{-GMm}{3R_E}$$

$$E_2 = \frac{-GMm}{2(3R_E)} = \frac{-GMm}{6R_E}$$

Energy Req : $E_2 - E_1 = \frac{-GMm}{6R_E} - \left(\frac{-GMm}{3R_E}\right)$

$$= \frac{GMm}{R_E}\left[\frac{1}{3} - \frac{1}{6}\right] = \left[\frac{GMm}{6R_E}\right]$$

$$= \frac{mgR_E}{6} = 10^9 \text{ J} \qquad \left[g = \frac{Gm}{(R_E)^2}\right]$$

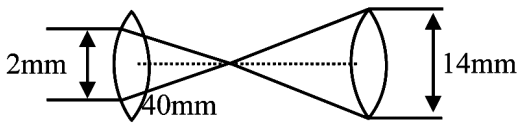
20. A collimated beam of light of diameter 2mm is propagating along x-axis. The beam is required to be expanded in a collimated beam of diameter 14mm using a system of two convex lenses. If first lens has focal length 40mm then focal length of 2nd lens is :

(1) 270 mm (2) 260 mm

(3) 290 mm (4) 280 mm

Ans. (4)

Sol.



Similar triangle

$$\frac{2}{40} = \frac{14}{f}$$

f = 280 mm

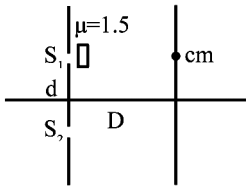
SECTION-B

21. In YDSE arrangement

$d = 0.1$ cm

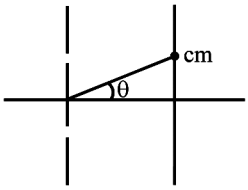
$D = 50$ cm

If a thin film placed as in the figure in front of S_1 central maxima forms 0.2 cm above centre. The thickness of film should be (in μm):



Ans. **(8)**

Sol.



$$\sin\theta = \tan\theta = \frac{0.2}{50} = \frac{1}{250}$$

$\Delta x_{cm} = 0$

$\Delta x_{cm} = (\mu - 1)t - d\sin\theta = 0$

$$0.5t = 0.1 \times 10^{-2} \times \frac{1}{250}$$

$$= 10^{-3} \times 4 \times 10^{-3} = 4 \times 10^{-6}$$

$t = 8 \times 10^{-6} = 8$ μm

22. Initial temperature of 10 moles O_2 is 30°C. Find change in internal energy (in calorie) if final temperature becomes 40°C. Given $C_P = \frac{7\text{cal}}{\text{mole°C}}$, $R = \frac{2\text{cal}}{\text{mole°C}}$

Ans. **(500)**

Sol. $\Delta U = nC_v\Delta T = n(C_P - R)(T_f - T_i)$

$\Delta U = 10(7 - 2)(40 - 30)$

$= 10 \times 5 \times 10$

$\Delta U = 500$ Calorie

23. Compound microscope has $f_0 = 2$ cm, $f_e = 4$ cm and tube length $\ell = 32$ cm. For normal adjustment find magnification.

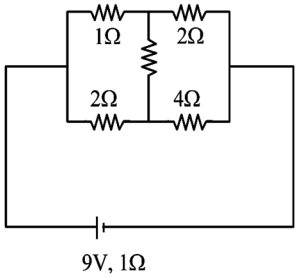
Ans. **(100)**

Sol. $$m \simeq \frac{\ell}{f_0}\frac{D}{f_e}$$

$$m \simeq \frac{32}{2} \times \frac{25}{4}$$

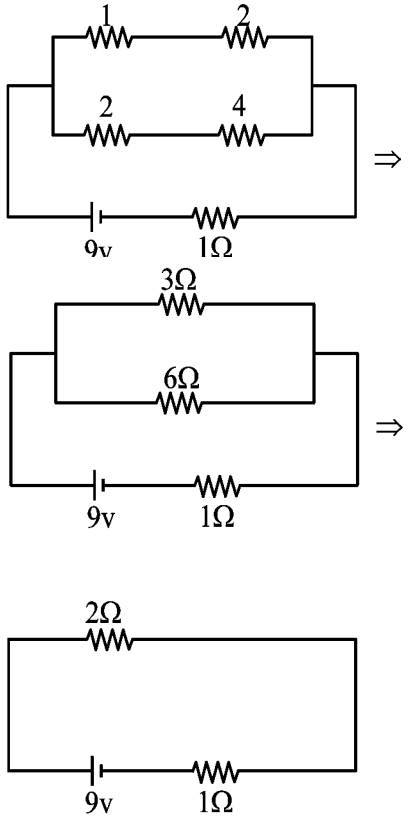
$m \simeq 100$

24. Find heat (in joule) dissipated in 1 minute in external circuit.



Ans. **(1620)**

Sol. It is wheatstone bridge



Req. $i = \frac{v}{Req} = \frac{9}{3} = 3$amp

Heat : $i^2Rt = (9)(3)(60) = 1620$ J

25. There are two springs of spring constant $k_1 = (20 \pm 0.3)$ N/m and $k_2 = (30 \pm 0.2)$ N/m. If they are connected in parallel then percentage error in equivalent spring constant of combination is _____%.

Ans. **(1)**

Sol. $\Delta k = \Delta k_1 + \Delta k_2 = 0.5$

Keq = 50 N/m

$$\% \text{ error} = \frac{0.5}{50} \times 100 = 1$$

SECTION-A

1. $PbCl_2 + K_2CrO_4 \rightarrow A + KCl$

$A + \underset{\text{(excess)}}{NaOH} \rightarrow B + Na_2CrO_4$

$PbSO_4 + CH_3COONH_4 \rightarrow C + (NH_4)_2SO_4$

Find A, B, C.

(1) A : $PbCrO_4$
B : PbO_2
C : $Pb(OH)_2$

(2) A : $PbCrO_4$
B : $Na_2[Pb(OH)_4]$
C : $Pb(CH_3COO)_2$

(3) A : $PbCrO_4$
B : PbO
C : $[Pb(NH_3)_4]^{2+}$

(4) A : PbO_2
B : $Pb(OH)_2$
C : $[Pb(CH_3COO)_4]^{2-}$

Ans. **(2)**

Sol. $PbCl_2 + K_2CrO_4 \rightarrow PbCrO_4 + KCl$

$PbCrO_4 + 2NaOH \text{ (excess)} \rightarrow Na_2[Pb(OH)_4] + Na_2CrO_4$

$PbSO_4 + 2CH_3COONH_4 \rightarrow Pb(CH_3COO)_2 + (NH_4)_2SO_4$

2. **Statement-I** : Among $[NiCl_4]^{2-}$, $[Ni(CN)_4]^{2-}$ $[Ni(CO)_4]$ & CH_4 the sp^3 hybridized species(s) are 3.

Statement-II : Number of Amphoteric pair(s) among (SnO, SnO_2) ; (PbO, PbO_2) ; (GeO, GeO_2) are 3.

(1) Both statements are correct
(2) Statement-I correct ; Statement-II incorrect
(3) Statement-II correct; Statement-I incorrect
(4) Both statements are incorrect

Ans. **(2)**

Sol. Statement-I $[NiCl_4]^{-2}$, $[Ni(CO)_4]$ & CH_4 are sp^3 Hybridised

$[NiCO_4] \rightarrow dsp^2$

Statement-II GeO and GeO_2 are acidic.

3. **Statement-I :**

Among SF_4, XeF_4, $[NiCl_4]^{2-}$, $[PtCl_4]^{2-}$, $[Pt(CN)_4]^{2-}$, $[Ni(CN)_4]^{2-}$, SeF_4 there are 3 tetrahedral species

Statement-II : Among three pairs {$[Ni(CO)_4]$, $[NiCl_4]^{-2}$}, {$[Ni(CO)_4]$, $[Ni(CN)_4]^{-2}$} and {$[Ni(CN)_4]^{-2}$, $[NiCl_4]^{-2}$} only two pairs are diamagnetic.

(1) Both statements are correct
(2) Statement-I correct ; Statement-II incorrect
(3) Statement-II correct; Statement-I incorrect
(4) Both statements are incorrect

Ans. **(4)**

Sol. SF_4(See-saw), XeF_4(square planar), $[NiCl_4]^{2-}$ (Tetrahedral), $[PtCl_4]^{2-}$(square planar), $[Pt(CN)_4]^{2-}$ (square planar), $[Ni(CN)_4]^{2-}$(square planar), SeF_4 $[Ni(CO)_4]$(diamagnetic), $[NiCl_4]^{-2}$(paramagnetic), $[Ni(CN)_4]^{-2}$(diamagnetic)

4. MnO_4^{2-} in acidic medium, disproportionates to

(1) Mn_2O_7 and MnO (2) MnO_4^- and MnO

(3) MnO_4^- and MnO_4 (4) MnO_4^- and MnO_2

Ans. **(4)**

Sol. $\overset{+6}{K_2MnO_4} \xrightarrow{H^+} \overset{+7}{KMnO_4} + \overset{+4}{MnO_2}$

5. Which of the following is the correct order with respect to the property indicated against it ?

(1) B > S > P > F (Ionization energy)
(2) $K_2O > Na_2O > MgO > Al_2O_3$ (Basic nature)
(3) K > Na > Al > Mg (Metallic character)
(4) Cl > F > S > P (EA)

Which of the following option is correct

(1) 1, 2, 3 are correct
(2) 2, 4 are correct
(3) 1, 2, 4 are correct
(4) 1, 2, 3 are correct

Ans. **(2)**

Sol. (1) On moving left to right in a period IE increases and from top to bottom in a group IE decreases.

(2) On moving left to right in a period metallic and basic character decreases.

(3) On moving top to bottom in a group metallic and basic character increases.

(4) EA : Group 17 > Group 16 > Group 15

6. Given below are two statement :

Statement-I : All the pair of molecules (PbO, PbO_2); (SnO, SnO_2) and (Geo, GeO_2) contains amphoteric oxides.

Statement-II : $AlCl_3$, BH_3, BeH_2 and NO_2 all have incomplete octet.

In the light of about statement, choose the correct option.

(1) Both statements are correct

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

(3) Statement-I incorrect; Statement-II correct

(4) Both statements are incorrect

Ans. **(3)**

Sol. Geo are GeO_2 are acidic in nature.

$AlCl_3$, BH_3, BeH_2 and NO_2 all have incomplete octet.

7. 14.0 gm calcium metal is allowed to react with excess HCl at 1.0 atm pressure & 273 K. Which of the following statement is incorrect ?

[Molar mass in $g\text{-}mol^{-1}$, Ca = 40, Cl = 35.5]

(1) 0.35 mole of H_2 gas is evolved

(2) The limiting reagent is calcium metal

(3) 33.3 g of $CaCl_2$ is produced

(4) 7.84 L of H_2 gas is evolved

Ans. **(3)**

Sol. $\underset{\frac{14}{40}}{Ca_{(s)}} + \underset{\text{excess}}{2HCl_{(g)}} \longrightarrow \underset{-}{CaCl_{2(s)}} + \underset{-}{H_{2(g)}}$

$= .35 \text{ mole} \qquad .35 \text{ mole} \qquad .35 \text{ mole}$

Volume of $H_{2(g)}$ evolved = $.35 \times 22.4 = 7.84$ L

(3) is wrong because weight of $CaCl_2 = .35 \times 111 = 38.85$ gm

8. 80 ml unknown gaseous hydrocarbon sparked in presence of 264 ml of O_2 gas. After complete combustion gaseous mixture cooled down to 278K & 1 atm then it's volume is equal to 224 ml. After passing the mixture through aqueous KOH volume becomes 64 ml then formula of hydrocarbon will be :

(1) C_2H_2 (2) C_2H_6

(3) C_2H_4 (4) C_4H_4 or None

Ans. **(1)**

Sol. $$C_xH_{y(g)} + \left(x + \frac{y}{4}\right)O_{2(g)} \longrightarrow xCO_{2(g)} + \frac{y}{2}H_2O_{(\ell)}$$

t=0	80	264	0	-
$t=t_{final}$	-	$264-80\left(x+\frac{y}{4}\right)$	80x	-

$$264-80\left(x+\frac{y}{4}\right)+80x=224$$

$$264-\frac{80y}{4}=224$$

$$40=\frac{80y}{4}\Rightarrow y=2$$

$$264-80\left(x+\frac{y}{4}\right)=64$$

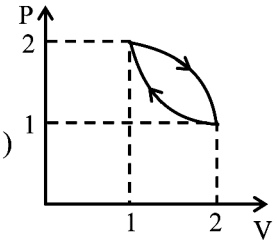
$$264-80\left(x+\frac{1}{2}\right)=64$$

$264 - 80x - 40 = 64$

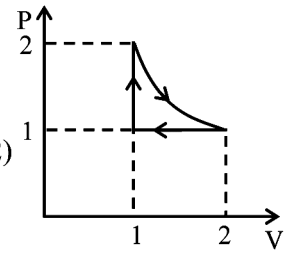
$x = 2$

9. One mole of the gas undergo following process :

(1)



(2)



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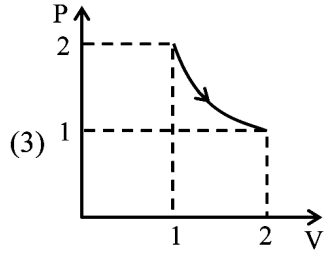
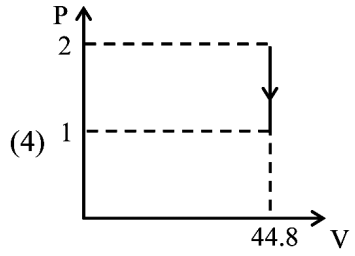


(4)



In which of the following work done by the gas is maximum.

Ans. **(3)**

Sol. Area of P v/s V curve is equal to work done by gas.

10. Two solution of PQ & PQ_2 respectively (Non-volatile, Non-ionisable) containing 1 gm solute in 50 gm solvent (K_b = 5 K-kg/mol) elevation in b.p. of solutions are 1.176°C & 0.689°C respectively. Calculate molar masses of P & Q ?

(1) 75, 25 (2) 60, 25

(3) 25, 60 (4) 25, 75

Ans. **(2)**

Sol. $(\Delta T_b)_{PQ} = K_b m$

$$1.176 = 5 \times \frac{1}{M_1} \times \frac{1000}{50}$$

$M_1 = 85.03$

$$(\Delta T_b)_{PQ_2} = 5 \times \frac{1}{M_2} \times \frac{1000}{50}$$

$M_2 = 145.13$

Let molar mass of P & Q are M_P and M_Q respectively

$M_P + M_Q = 85.03$

$M_P + 2M_Q = 145.13$

$M_Q = 60.1 \approx 60$

$M_P = 24.93 \approx 25$

11. For the reaction : $A_2 + B_2 \xrightarrow{500K} 2AB$: $\log K = 2.2$

	H_f^0 (KJ/mole)	S_f^0 (J/K-mole)
AB	32	240
A_2	6	224
B_2	x	238

Calculate the value of x.

(1) 70 (2) 60

(3) 50 (4) 80

Ans. **(1)**

Sol. $A_2 + B_2 \xrightarrow{500K} 2AB \ \log K = 2.2$

$\Delta H° = (2 \times 32) - (6 + x) = (58 - x)$ kJ

$\Delta S° = (2 \times 240) - (224 + 238) = 18$ Joule

$\Delta G° = -RT\ln K$

$$\Delta G° = -\frac{8.314 \times 500 \times 2.2 \times 2.303}{1000}$$

$\Delta G° = -21.06$

$\Delta H° - T\Delta S° = -21.06$

$$58 - x - 500\left(\frac{18}{1000}\right) = -21.06$$

x = 70.06 KJ/mol

12. **Statement-1 :** Electrical discharge is passed through the H_2 gas. H_2 dissociates into H atoms & the energetically excited atoms emit discrete frequencies.

Statement-2 : Frequency of 2nd balmer line of He^+ is equal to 1st line of lyman series of H atom.

(1) Both statements are correct.

(2) Both statements are incorrect.

(3) Statement-1 is correct and statement-2 is incorrect.

(4) Statement-1 is incorrect and statement-2 correct.

Ans. **(1)**

Sol. $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For Ist line of lyman series in H-atom

$$\frac{1}{\lambda} = R(1)^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

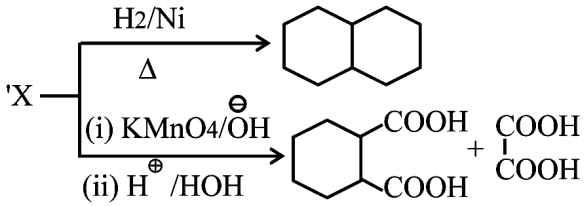
$$\frac{1}{\lambda} = \frac{3R}{4}$$

for 2nd line of Balmer series of He^+

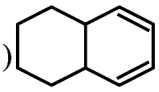
$$\frac{1}{\lambda'} = R(2)^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

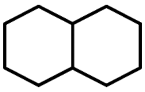
$$\frac{1}{\lambda'} = \frac{3R}{4}$$

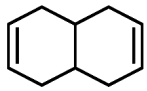
As λ and λ' is equal so frequency of these lines will be also equal.

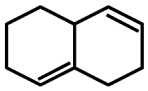
13. 

X is :

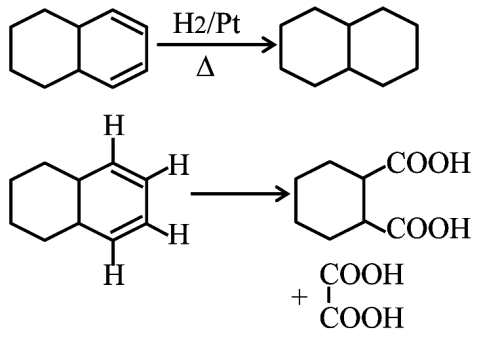
(1) 

(2) 

(3) 

(4) 

Ans. (1)

Sol. 

14. Compound P when pass on from ammonia & heating gives compound Q which is further treated with KOH + Br_2 gives compound R with mol. formula C_6H_7N then find the correct structure of P, Q, R respectively.

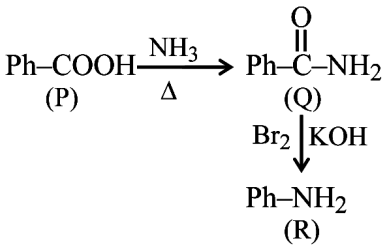
(1) Benzoic acid, bezamide, aniline

(2) Benzoic acid, ammonium benzoate, benzene

(3) Ammonium benzoate, benzamide, benzene

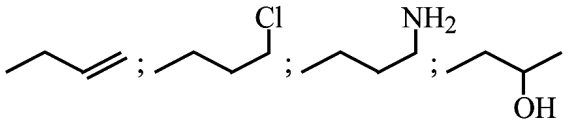
(4) Benzoic acid, aniline, benzene

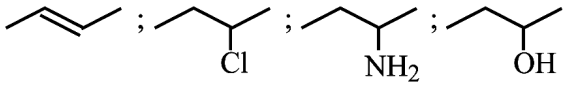
Ans. (1)

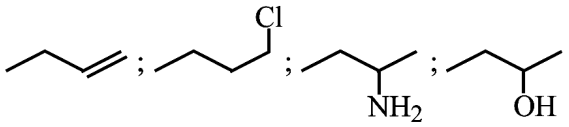
Sol. 

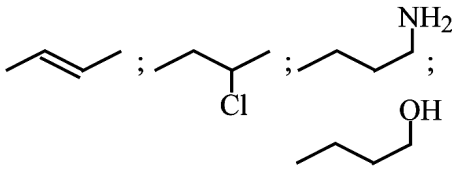
15. An Alkene P (C_4H_8), gives optically active product Q which further react with ammonia and gives R. R react with $NaNO_2$ + HCl followed by hydrolysis gives S.

P, Q, R, S are respectively :

(1) 

(2) 

(3) 

(4) 

Ans. (2)

16. **Statement-A :** Tryptophan, arginine are essential amino acid.

Statement-B : Glycine has no chiral center

Statement-C : Proline has 6-membered ring

Statement-D : Cysteine is amino acid having sulphur atom

Identify correct statement.

(1) A, B

(2) A, B, D

(3) A, C, D

(4) A, B, C

Ans. (2)

17. **Statement-A :** Propanal & propanone are functional group isomers.

Statement-B : Ethoxy ethane and methoxy propane are metamers.

Statement-C : But-2-ene show optical isomerism.

Statement-D : But-2-ene and But-1-ene are functional isomers.

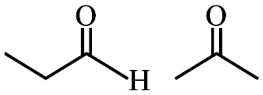
Statement-E : Pentane & 2,2-dimethyl propane are chain isomers.

Identify the correct statement.

(1) A, B. E (2) A, B, C

(3) B, E (4) A, B

Ans. (1)

Sol.  ⇒ Functional isomer

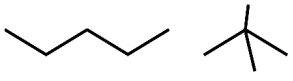
$CH_3–CH=CH–CH_3$ & $CH_3–CH_2–CH=CH_2$

Position isomer

$CH_3–CH_2–O–CH_2–CH_3$ & $CH_3–CH_2–CH_2–O–CH_3$

Metamer

$CH_3–CH=CH–CH_3$ show G.I. not optical iosomer

 Chain isomer

18. In Carrius method, 0.75 gm of an organic compound gave 1.2 gm of barium sulphate, find % of sulphur (molar mass of S is 32 gm mol^{-1})

Molar mass of barium sulphate is 233 gm mol^{-1}

(1) 16.48 % (2) 4.55 %

(3) 21.97 % (4) 10.30 %

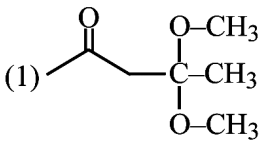
Ans. (3)

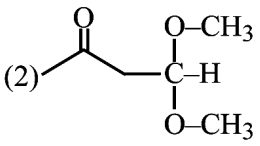
Sol. $$\frac{n_{BaSO_4} \times 32}{W_{(unknown\ comp.)}} \times 100$$

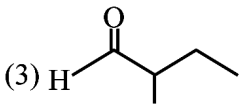
$$= \frac{1.2 \times 32}{233} \times 100$$

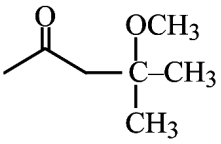
$$= 21.97\%$$

19. Compound A gives +ve idoform test but –ve tollen's test. Acidic hydrolysis of A gives product P which gives positive tollen's test and also positive iodoform test. Compound A can be :

(1) 

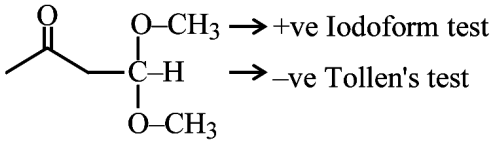
(2) 

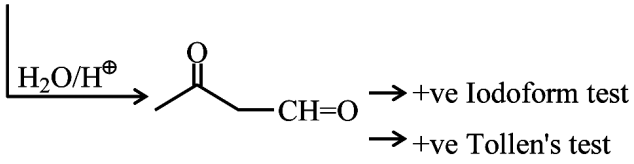
(3) 

(4) 

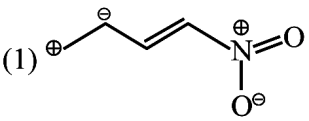
Ans. (2)

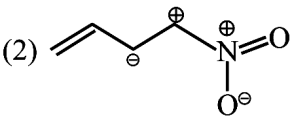
Sol.

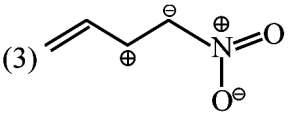


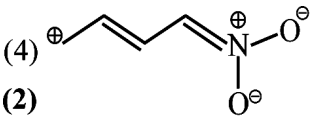


20. Which of the following least stable resonating structure ?

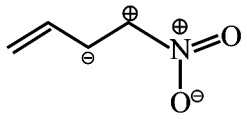
(1) 

(2) 

(3) 

(4) 

Ans. (2)

Sol. 

This resonating structure having +ve charge on adjacent atoms so it is least stable.

SECTION-B

1. For two chemical reaction A & B, if the difference between their activation energy is 20 KJ of 300K determine $\ln\left(\frac{k_2}{k_1}\right)$:

[R=8.3 J/mol-K]

Ans. (8)

Sol. $A \xrightarrow{RX^n(1)} \text{product}\ \ E_1$

$B \xrightarrow{RX^n(2)} \text{product}\ \ E_2$

Assuming 'A' same for both reaction.

$$\ln k_1 = \ln A - \frac{E_1}{300R}$$

$$\ln k_1 = \ln A - \frac{E_2}{300R}$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_1 - E_2}{300R} = \frac{20\times1000}{300R}$$

$= 8.032$

2. 10 moles of O_2 gas is heated at constant volume from 30°C to 40°C. The change in the internal energy of gas is _____ cal.

$C_P = 7$ Cal/mol-K, $R = \frac{2\,\text{Cal}}{\text{mol}-\text{K}}$

Ans. (500 Cal)

Sol. $C_P - C_V = R$

$7 - C_V = 2$

$C_V = 5$ Cal/mol-K

$\Delta U = nC_V\,\Delta T$

$= 10 \times 5\ [10]$

$= 500$ Cal

3. pH & conductance of a standard solution of HX are 5 & 4×10^{-5} S respectively. The standard solution is present in cell having length between electrodes 15 cm & Area is 1 cm^2 then calculate limiting molar conductivity(Sm^2mol^{-1}) of standard solution.

[Assume degree of dissociation of HX << 1]

Ans. (6)

Sol. pH = 5

$[H^+] = 10^{-5} = [HX].\alpha$

$$= [HX].\frac{\Lambda_m}{\Lambda_m^\infty}$$

$$\Lambda_m = \frac{k\times1000}{[HX]}$$

$$K = G.G^* = 4\times10^{-5}\times\frac{15}{1} = 6\times10^{-4}\ S.cm^{-1}$$

$$[H^+] = 10^{-5} = [HX]\times\frac{6\times10^{-4}\times1000}{\Lambda_m^\infty\times[HX]}$$

$\Lambda_m^\infty = 60000\ S.cm^{-1}\ mol^{-1}$

$\Lambda_m^\infty = 6\ S.m^2\ mol^{-1}$

4. $NaCl(s) + K_2Cr_2O_7(s) \xrightarrow[H_2SO_4]{Conc} A$

$A \xrightarrow{NaOH} B$

$B \xrightarrow{H_2O_2/H_2SO_4} C$

If number of O_2^{2-} ion in C = X

If number of O atom in C = Y

If oxidation state of Cr in C = Z

Then (X + Y + Z) is _

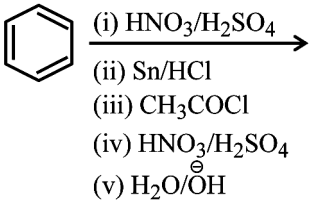
Ans. (13)

Sol. $NaCl(s) + K_2Cr_2O_7\,(s) \xrightarrow[H_2SO_4]{conc.} CrO_2Cl_2$

$CrO_2Cl_2 + NaOH \longrightarrow Na_2CrO_4$

$Na_2CrO_4 + H_2O_2 \xrightarrow{H^+} CrO_5$

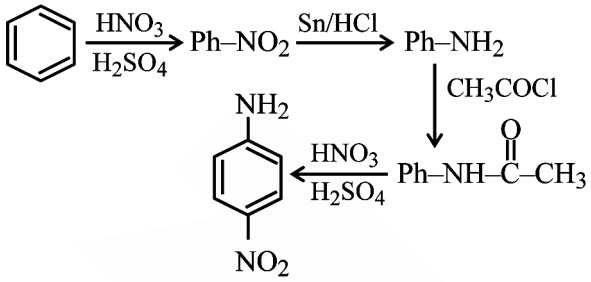
X = 2, Y = 5, Z = 6

5. 

Find % of N in the final product.

Ans. 20.29%

Sol.



Mol. wt = (6 × 12) + (6 × 1)+ (2 × 14) + (2 × 16)
= 138

$$\%N = \frac{28}{138} \times 100 = 20.29\%$$