TEST CODE : 122006

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IIT-JEE

Batch – Excel (April) | Minor Test-07

Time: 3 Hours | **Test Date: 7th September 2025** | **Maximum Marks: 300**

Name of the Candidate: ____ Roll No.______________

Centre of Examination (in Capitals):____

Candidate's Signature:_____________________________ Invigilator's Signature:____________________________

READ THE INSTRUCTIONS CAREFULLY

1. The candidates should not write their Roll Number anywhere else (except in the specified space) on the Test Booklet/Answer Sheet.

2. This Test Booklet consists of 75 questions.

3. This question paper is divided into three parts **PART A - MATHEMATICS, PART B - PHYSICS** and **PART C - CHEMISTRY** having 25 questions each and every **PART** has two sections.

(i) **Section-I** contains 20 multiple choice questions with only one correct option. Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

(ii) **Section-II** contains 5 questions with INTEGERAL VALUE.

Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

4. No candidate is allowed to carry any textual material, printed or written, bits of papers, mobile phone any electronic device etc., except the Identity Card inside the examination hall/room.

5. Rough work is to be done on the space provided for this purpose in the Test Booklet only.

6. On completion of the test, the candidate must hand over the Answer Sheet to the invigilator on duty in the Room/Hall. However, the candidate is allowed to take away this Test Booklet with them.

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TEST SYLLABUS

Batch – Excel (May) | Minor Test-06

7th September 2025

Mathematics	: Application of Derivatives-Tangent & Normal, Rate Measure, Monotonicity, Mean Value Theorems, Maxima & Minima
Physics	: Alternating Current
Chemistry	: Optical isomerism & Alkyl Halide

Useful Data Chemistry:

Gas Constant	R	$= 8.314\,JK^{-1}mol^{-1}$
		$= 0.0821$ Lit atm $K^{-1}mol^{-1}$
		$= 1.987 \approx 2$ Cal $K^{-1}mol^{-1}$
Avogadro's Number	N_a	$= 6.023 \times 10^{23}$
Planck's Constant	h	o
		$= 6.25 \times 10^{-27}$ erg.s
1 Faraday		= 96500 Coulomb
1 calorie		= 4.2 Joule
1 amu		$= 1.66 \times 10^{-27}$ kg
1 eV		$= 1.6 \times 10^{-19}$ J

Atomic No:
H = 1, D = 1, Li = 3, Na = 11, K = 19, Rb = 37, Cs = 55, F = 9, Ca = 20, He = 2, O = 8, Au = 79.

Atomic Masses:
He = 4, Mg = 24, C = 12, O = 16, N = 14, P = 31, Br = 80, Cu = 63.5, Fe = 56, Mn = 55, Pb = 207, Au = 197, Ag = 108, F = 19, H = 2, Cl = 35.5, Sn = 118.6

Useful Data Physics:
Acceleration due to gravity $g = 10\ m / s^2$

PART-A: MATHEMATICS

SECTION-A

1. The function $f(x)=\frac{x}{\sqrt{x+1}}-\ln(1+x)$ is an increasing function in the interval.

(A) $[-1,\infty)$

(B) $(-1,\infty)$

(C) $(-\infty,\infty)$

(D) $(0,\infty)$

Ans. (B)

$f(x)=x/\sqrt{(x+1)}-\ln(1+x);\ x\neq-1$

Differentiating w.r.t. x, we get

$$f'(x)=\frac{1\sqrt{x+1}-x\frac{1}{2\sqrt{x+1}}}{(x+1)}-\frac{1}{1+x};x\neq-1$$

$$f'(x)=\frac{2(x+1)-x}{2\sqrt{x+1}(x+1)}-\frac{1}{1+x}=\frac{(x+1)+1-2(\sqrt{x+1})}{2\sqrt{x+1}(x+1)}$$

$$f'(x)=\frac{\left(\sqrt{x+1}-1\right)^2}{2\sqrt{x+1}(x+1)}$$

$f'(x)>0$ as given $x>-1$

Sol. Hence, f(x) is an increasing function.

2. Let $f(x)=\sin^4 x+\cos^4 x$. Then f is an increasing function in the interval:

(A) $\left[\frac{5\pi}{8},\frac{3\pi}{4}\right]$

(B) $\left[\frac{\pi}{2},\frac{5\pi}{8}\right]$

(C) $\left[\frac{\pi}{4},\frac{\pi}{2}\right]$

(D) $\left[0,\frac{\pi}{4}\right]$

Ans. (C)

Sol. $f(x)=\sin^4 x+\cos^4 x$

$f'(x)=4\sin^3 x\cos x+4\cos^3 x(-\sin x)$

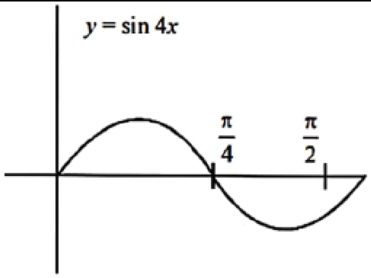
$=4\sin x\cos x\left(\sin^2 x-\cos^2 x\right)$

$=-2\sin 2x\cos 2x=-\sin 4x$

$f(x)$ is increasing when $f'(x)>0$

$\Rightarrow -\sin 4x>0\Rightarrow \sin 4x<0$

$\Rightarrow x\in\left(\frac{\pi}{4},\frac{\pi}{2}\right]$



3. Local maximum and local minimum values of the function $(x-1)(x+2)^2$ respectively are

(A) -4,0
(B) 0,-4
(C) 4,0
(D) None of these

Ans. (B)

$f(x) = (x-1).(x+2)^2$

$f'(x) = (x+2)3x = 0$

$x = 0, -2$

$x = -2, f'(x)$ changes from +ve to −ve

Hence, $x = -2$ is point of maxima,

$f(-2) = 0$

At $x = 0, f'(x)$ changes from −ve to +ve

Hence, x = 0 is point of minima,

Sol. $f(0) = -4$.

4. If $g(x) = 7x^2 \cdot e^{-x^2} \forall x \in R$, then g(x) has

(A) local minima at x=0
(B) local maxima at x=0
(C) local maxima at x=1
(D) one local maxima and two local minima

Ans. (A)

$f'(x) = \left(14x - 14x^3\right).e^{-x^2}$

Sol. $f'(x) = 14x(1-x)(1+x)e^{-x^2}$

5. If x=1 is a critical point of the function $f(x) = \left(3x^2 + ax - 2 - a\right)e^x$, then :

(A) x=1 and $x = -\frac{2}{3}$ are local minima of f.

(B) x=1 and $x = -\frac{2}{3}$ are local maxima of f.

(C) x=1 is a local maxima and $x = -\frac{2}{3}$ is a local minima of f.

(D) x=1 is a local minima and $x = -\frac{2}{3}$ is a local maxima of f.

Ans. (D)

Sol.

The given function

$f(x) = (3x^2 + ax - 2 - a)e^x$

$f'(x) = (6x + a)e^x + (3x^2 + ax - 2 - a)e^x$

$f'(x) = [3x^2 + (a+6)x - 2]e^x$

$\because x = 1$ is critical point :

$\therefore f'(1) = 0$

$\Rightarrow (3 + a + 6 - 2) . e = 0$

$\Rightarrow a = -7 \quad (\because e > 0)$

$\therefore f'(x) = (3x^2 - x - 2)e^x$

$= (3x+2)(x-1)e^x$

+   −   +

$-2/3$ 1

$\therefore x = -\frac{2}{3}$ is point of local maxima.

and $x = 1$ is point of local minima.

6. The function $f(x) = \frac{x}{2} + \frac{2}{x}$ has a local minimum at

(A) x=2

(B) x=-2

(C) x=0

(D) x=1

Ans. (A)

Sol. Given $f(x) = \frac{x}{2} + \frac{2}{x} \Rightarrow f'(x) = \frac{1}{2} - \frac{2}{x^2} = 0$

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

7. A point on the parabola $y^2 = 18x$ at which the ordinate increases at twice the rate of the abscissa is

(A) $\left(\frac{9}{8}, \frac{9}{2}\right)$

(B) $(2, -4)$

(C) $\left(\frac{-9}{8}, \frac{9}{2}\right)$

(D) $(2, 4)$

Ans. (A)

Sol. $Given\ y^2 = 18x \Rightarrow 2y\frac{dy}{dx} = 18 \Rightarrow \frac{dy}{dx} = \frac{9}{y}$

$\text{ATQ} \frac{dy}{dt} = \frac{2dx}{dt} \Rightarrow \frac{dy}{dx} = 2$

$\Rightarrow \frac{9}{y} = 2 \Rightarrow y = \frac{9}{2}$

$Putting\ in\ y^2 = 18x \Rightarrow x = \frac{9}{8}$

$\therefore Required\ point\ is \left(\frac{9}{8}, \frac{9}{2}\right)$

8. If the function $f(x) = 2x^3 - 9ax^2 + 12a^2x + 1$, where a>0, attains its maximum and minimum at p and q respectively such that $p^2 = q$, then a equals

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

(B) 3

(C) 1

(D) 2

Ans. (D)

Sol.

$f(x) = 2x^3 - 9ax^2 + 12a^2x + 1$

$f'(x) = 6x^2 - 18ax + 12a^2$

For maxima or minima.

$6x^2 - 18ax + 12a^2 = 0 \Rightarrow x^2 - 3ax + 2a^2 = 0$

$\Rightarrow x = a$ or $x = 2a$

$f''(x) = 12x - 18a$

$f''(a) = -6a < 0 \therefore f(x)$ is max. at $x = a$

$f''(2a) = 6a > 0$

$\therefore f(x)$ is min. at $x = 2a$

$\therefore p = a$ and $q = 2a$

AT Q, $p^2 = q$

$\therefore a^2 = 2a \Rightarrow a = 2$ or $a = 0$

but $a > 0$, therefore, $a = 2$.

9. Number of real roots of cubic polynomial $f(x) = x^3 - 3x^2 + 7x + 3$ are:

(A) 1
(B) 2
(C) 3
(D) None of these

Ans. (A)

Sol. $f(x) = x^3 - 3x^2 + 7x + 3$

$f'(x) = 3x^2 - 6x + 7 > 0 \quad \forall x \in R$

10. If Rolle's theorem holds for the function $f(x) = x^3 - ax^2 + bx - 4, x \in [1, 2]$ with $f'\left(\frac{4}{3}\right) = 0$, then ordered pair (a, b) is equal to:

(A) (-5, -8)

(B) (5, -8)

(C) (-5, 8)

(D) (5, 8)

Ans. (d)

$f(1) = f(2)$

$\Rightarrow 1 - a + b - 4 = 8 - 4a + 2b - 4$

$3a - b = 7$ ..... (1)

$f'(x) = 3x^2 - 2ax + b$

$\Rightarrow f'\left(\frac{4}{3}\right) = 0 \Rightarrow 3 \times \frac{16}{9} - \frac{8}{3}a + b = 0$

$\Rightarrow -8a + 3b = -16$ ..... (2)

Sol. $\therefore a = 5, b = 8$

11. The function f defined by $f(x) = x^3 - 3x^2 + 5x + 7$, is:

(A) increasing in R .
(B) decreasing in R .
(C) decreasing in (0, ∞) and increasing in (-∞ 0).
(D) increasing in (0, ∞) and decreasing in (-∞ 0).

Ans. (A)

$f(x) = x^3 - 3x^2 + 5x + 7$
For increasing
$f'(x) = 3x^2 - 6x + 5 > 0$
$\Rightarrow x \in R$
For decreasing

Sol. $f'(x) = 3x^2 - 6x + 5 < 0$

12. A spherical iron ball of 10 cm radius is coated with a layer of ice of uniform thickness that melts at a rate of $50\,\text{cm}^3/\text{min}$. When the thickness of ice is 5 cm , then the rate (in cm/min.) at which of the thickness of ice decreases, is:

(A) $\frac{5}{6\pi}$

(B) $\frac{1}{54\pi}$

(C) $\frac{1}{36\pi}$

(D) $\frac{1}{18\pi}$

Ans. (D)

Let the thickness of ice layer be $= x\text{cm}$

Total volume $V = \frac{4}{3}\pi(10+x)^3$

$\frac{dV}{dt} = 4\pi(10+x)^2\frac{dx}{dt}$ .....(i)

Since, it is given that

$\frac{dV}{dt} = 50\text{cm}^3/\text{min}$ ......(ii)

From (i) and (ii), $50 = 4\pi(10+x)$

$\Rightarrow 50 = 4\pi(10+5)^2\frac{dx}{dt}$ [$\because$ thickness of ice $x = 5$]

$\Rightarrow \frac{dx}{dt} = \frac{1}{18\pi}\text{cm/min}$

Sol.

13. If the function $f(x) = 2x^3 - 9ax^2 + 12a^2x + 1$, where a>0, attains its local maximum and local minimum values at p and q, respectively, such that $p^2 = q$, then f(3) is equal to:

(A) 55
(B) 37
(C) 10
(D) 23

Ans. (B)

To determine the value of $f(3)$ for the function $f(x) = 2x^3 - 9ax^2 + 12a^2x + 1$, where $a > 0$, we follow these steps:

First, find the critical points by setting the derivative equal to zero:

$f'(x) = 6x^2 - 18ax + 12a^2 = 0$

Factoring gives:

$6(x-a)(x-2a) = 0$

Thus, the critical points are $x = a$ and $x = 2a$.

$x = a$ corresponds to a local maximum.

$x = 2a$ corresponds to a local minimum.

According to the problem, $p^2 = q$. Substituting $p = a$ and $q = 2a$ gives:

$a^2 = 2a$

Solving for a gives:

$a(a-2) = 0$

Since $a > 0$, we have $a = 2$.

Now, substitute $a = 2$ back into the function:

$f(x) = 2x^3 - 18x^2 + 48x + 1$

To find $f(3)$:

$f(3) = 2(3)^3 - 18(3)^2 + 48(3) + 1$

Calculate each term:

$2(3)^3 = 54$

$18(3)^2 = 162$

$48(3) = 144$

Thus,

$f(3) = 54 - 162 + 144 + 1 = 37$

Sol. So, $f(3) = 37$.

14. The point of inflection for the curve $y = x^{\frac{5}{3}}$ is -

(A) (1, 1)
(B)(0, 0)
(C) (1, 0)
(D) (0, 1)

Ans. (B)

Sol. $Here\ \frac{d^2y}{dx^2} = \frac{10}{9x^{\frac{1}{3}}}$

From the given points we find that (0,0) is the point of the curve where $\frac{d^2y}{dx^2}$ does not exist but sign of $\frac{d^2y}{dx^2}$ changes about this point.

$\therefore$ (0,0) is the required point

15. If the minimum value of $f(x) = \frac{5x^2}{2} + \frac{a}{x^5}, x > 0$, is 14 , then the value of α is equal to:

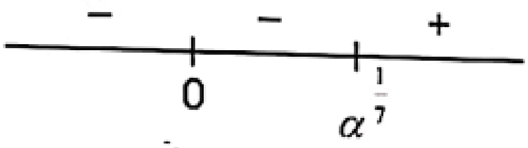
(A) 32
(B) 64
(C) 128
(D) 256

Ans. (C)

$$f(x) = \frac{5x^2}{2} + \frac{\alpha}{x^5}\{x > 0\}$$

$$f'(x) = 5x - \frac{5\alpha}{x^6} = 0$$

$$\Rightarrow x = (\alpha)^{\frac{1}{7}}$$



$$f(x)_{min} = \frac{5(\alpha)^{\frac{2}{7}}}{2} + \frac{\alpha}{\alpha^{\frac{5}{7}}} = 14$$

$$\frac{5}{2}\alpha^{\frac{2}{7}} + \alpha^{\frac{2}{7}} = 14$$

$$\frac{7}{2}\alpha^{\frac{2}{7}} = 14$$

Sol. $\alpha = 128$

16. If $f(x) = 2x^3 - 3x^2 - 36x + 6$ has local maximum and minimum at x=a and x=b respectively, then ordered pair (a, b) is -

(A) (3,-2)
(B) (2,-3)
(C) (-2,3)
(D) (-3,2)

Ans. (C)

$f(x) = 2x^3 - 3x^2 - 36x + 6$

$f'(x) = 6x^2 - 6x - 36$ and $\quad f''(x) = 12x - 6$

Now $f'(x) = 0 \Rightarrow 6(x^2 - x - 6) = 0 \Rightarrow (x - 3)(x + 2) = 0 \Rightarrow x = -2, 3$

$f''(-2) = -30$

$\therefore x = -2$ is a point of local maximum

$f''(3) = 30$ $\quad \therefore$ $x = 3$ is a point of local minimum

Sol. Hence, $(-2, 3)$ is the required ordered pair.

17. A rectangular sheet of fixed perimeter with sides having their lengths in the ratio 8: 15 is converted into an open rectangular box by folding after removing squares of equal area from all four corners. If the total area of removed squares is 100, the resulting box has maximum volume. The lengths of the sides of the rectangular sheet are

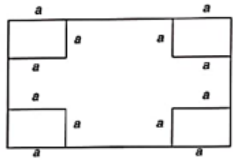
(a) 24

(b) 32

(c) 44

(d) 60

Ans. (A)



Let $l = 15x$ and $b = 8x$

Then Volume $= V = (8x - 2a)(15x - 2a).a$

$= 4a^3 - 46a^2x + 120ax^2$

$dV/da = 6a^2 - 46ax + 60x^2$

$d^2V/da^2 = 12a - 46x$

Now, $dV/da = 0$ gives

$\Rightarrow 6a^2 - 46ax + 60x^2 = 0$

$\Rightarrow 30x^2 - 23ax + 3a^2 = 0$

$\Rightarrow 30x^2 - 18ax - 5ax + 3a^2 = 0$

$\Rightarrow 6x(5x - 3a) - a(5x - 3a) = 0$

$\Rightarrow (6x - a)(5x - 3a) = 0$

$\Rightarrow x = a/6, 3a/5$

$\Rightarrow x = 5/6, 3$ when $a = 5$

When $x = 3$, $a = 5$, $d^2V/da^2 < 0$

So the Volume is maximum.

Sol. Hence, the lengths are $l = 15.3 = 45$ and $b = 8.3 = 24$.

18. If f(x) is continuous and differentiable over [-2,5] and $-4 \le f'(x) \le 3$ for all x in (-2,5), then the greatest possible value of f(5)-f(-2) is –

(A) 7

(B) 9

(C) 15

(D) 21

Ans. (D)

Sol. Apply LMVT

$$f'(x)=\frac{f(5)-f(-2)}{5-(-2)}$$ for some x in (-2,5)

Now, $-4\le\frac{f(5)-f(-2)}{7}\le3$

$-28\le f(5)-f(-2)\le21$

$\therefore$ Greatest possible value of f(5)-f(-2) is 21 .

19. Let $\mathbf{f}:\mathbb{R}\to\mathbb{R}$ be a polynomial function of degree four having extreme values at x=4 and x=5. If $\lim_{x\to0}\frac{f(x)}{x^2}=5$, then f(2) is equal to:

(A) 8
(B) 10
(C) 12
(D) 14

Ans. (B)

$\lim_{x\to0}\frac{f(x)}{x^2}=5$

$\lim_{x\to0}\frac{ax^4+bx^3+cx^2+dx+e)}{x^2}=5$

$c=5$ and $d=e=0$

$f(x)=ax^4+bx^3+5x^2$

$f'(x)=4ax^3+3bx^2+10x$

$=x\left(4ax^2+3bx+10\right)$

has extremes at 4 and so $f'(4)=0\&f'(5)=0$

so $\mathrm{a}=\frac{1}{8}\&\ \mathrm{b}=\frac{-3}{2}$

so $f(2)=\frac{1}{8}\times2^4-\frac{3}{2}\times2^3+5\times2^2$

$=2-12+20=10$

Sol.

20. Let g(x)=3 f(x / 3)+f(3-x) and $f''(x)>0$ for all $x\in(0,3)$. If g is decreasing in (0,α) and increasing in $(\alpha,3)$, then 8α is

(A) 24
(B) -19
(C) 18
(D) 20

Ans. (C)

$g(x) = 3f\left(\frac{x}{3}\right) + f(3-x)$ and $f''(x) > 0 \ \forall x \in (0, 3)$

$\Rightarrow f'(x)$ is increasing function

$g'(x) = 3 \times \frac{1}{3} \cdot f'\left(\frac{x}{3}\right) - f'(3-x)$

$= f'\left(\frac{x}{3}\right) - f'(3-x)$

If g is decreasing in $(0, \alpha)$

$g'(x) < 0$

$f'\left(\frac{x}{3}\right) - f'(3-x) < 0$

$f'\left(\frac{x}{3}\right) < f'(3-x)$

$\Rightarrow \frac{x}{3} < 3 - x$

$\Rightarrow x < \frac{9}{4}$

Therefore $\alpha = \frac{9}{4}$

Then $8\alpha = 8 \times \frac{9}{4} = 18$

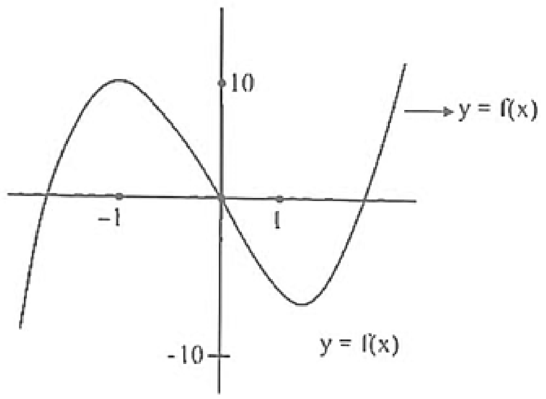
Sol.

SECTION-B

21. If the set of all values of a, for which the equation $5x^3 - 15x - a = 0$ has three distinct real roots, is the interval (α, β), then $\beta - 2\alpha$ is equal to ____.

Ans. (30)

$5x^3 - 15x - a = 0$
$f(x) = 5x^3 - 15x$
$f'(x) = 15x^2 - 15 = 15(x-1)(x+1)$



$a \in (-10, 10)$
$\alpha = -10, \beta = 10$
$\beta - 2\alpha = 10 + 20 = 30$

Sol.

22. If range of $f(x) = x^3 - 7x^2 + 20x + 5$ in the interval [-1,1] is [a, b] then value of |a+b| is

Ans. (4)

Sol. $f'(x) = 3x^2 - 14x + 20 > 0 \forall x \in R$

$f(-1) = -1 - 7 - 20 + 5 = -23$

$f(1) = 1 - 7 - 20 + 5 = 19$

$|-23 + 19| = 4$

23. Minimum integral value of $f(x) = \ln(1+x) - \frac{x}{(1+x)}$.

Ans. (0)

Sol.

$f'(x) = \frac{1}{1+x} - \frac{1}{(1+x)^2}$

$f'(x)$ is always positive in the interval $(0, \infty)$

$f'(x)$ is negative in the interval $(-1, 0)$

the function is decreasing in the interval $(-1, 0)$ and increasing in the interval $(0, \infty)$

$f(-1^+) \to \infty$

then the minimum value of $f(x)$ is at $x = 0$

$f(0) = 0$

24. If the cubic polynomial $y = ax^3 + bx^2 + cx + d (a, b, c, d \in R)$ has only one critical point in its entire domain and ac=2, then the value of b^2.

Ans. (6)

Sol. $\frac{dy}{dx} = 3ax^2 + 2bx + c = 0$ has one root $\Rightarrow D = b^2 - 3ac = 0 \Rightarrow b^2 = 6$

25. A wire of length 36 m is cut into two pieces, one of the pieces is bent to form a square and the other is bent to form a circle. If the sum of the areas of the two figures is minimum and the circumference of the circle is $\mathbf{k(m)}$, then $\left(\frac{4}{\pi} + \mathbf{1}\right)\mathbf{k}$ is equal to

Ans. (36)

Sol.

Let x + y = 36

where, x is perimeter of square and y is perimeter of circle

Then, side of square $= \frac{x}{4}$ and radius of circle $= \frac{y}{2\pi}$

Now, Sum of areas of square and circle, $A = \frac{x^2}{16} + \frac{y^2}{4\pi}$

$\Rightarrow A = \frac{x^2}{16} + \frac{(36-x)^2}{4\pi}$ $[\because y = 36 - x]$

For minimum area

$\frac{dA}{dx} = 0$

Now, $\frac{dA}{dx} = \frac{2x}{16} + \frac{-2(36-x)}{4\pi} = 0$

$\Rightarrow x = \frac{144}{\pi + 4}$

Circumference of circle = y

$= (36 - x)$

$= 36 - \frac{144}{\pi+4} = \frac{36\pi}{\pi+4}$

According to the question,

$k = \frac{36\pi}{\pi+4}$

$\Rightarrow \left(\frac{4}{\pi}+1\right)k = \left(\frac{4}{\pi}+1\right)\frac{36\pi}{\pi+4} = 36$

PART-B: PHYSICS

SECTION-A

26. A lamp consumes only 50% of peak power in an a.c. circuit. What is the phase difference between the applied voltage and the circuit current

(A) $\frac{\pi}{6}$

(B) $\frac{\pi}{3}$

(C) $\frac{\pi}{4}$

(D) $\frac{\pi}{2}$

Ans. (B)

Sol.

$P = \frac{1}{2}V_0 i_0 \cos\phi \Rightarrow P = P_{Peak}.\cos\phi$

$\Rightarrow \frac{1}{2}(P_{peak}) = P_{peak}\cos\phi \Rightarrow \cos\phi\frac{1}{2} \Rightarrow \phi = \frac{\pi}{3}$

27. An LCR series circuit is at resonance. Then,

(A) The phase difference between current and voltage is 90°

(B) The phase difference between current and voltage is 45°

(C) Its impedance is purely resistive

(D) Its impedance is zero

Ans. (C)

Sol.

In series LCR, the impedance of the circuit is given by

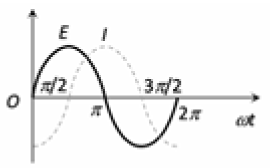
$Z = \sqrt{R^2 + (X_L - X_C)^2}$

At resonance, $X_L = X_C$

$\therefore Z = R$

At resonance, the phase difference between the current and voltage is 0°. Current is maximum at resonance

28. The variation of the instantaneous current (I)and the instantaneous emf (E) in a circuit is as shown in fig. Which of the following statements is correct



(A) *The voltage lags behind the current by* $\pi / 2$

(B) *The voltage leads the current by* $\pi / 2$

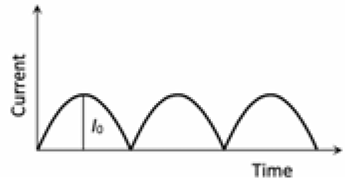
(C) *The voltage and the current are in phase*

(D) *The voltage leads the current by* π

Ans. (B)

Sol. At $t = 0$, phase of the voltage is zero, while phase of the current is $-\frac{\pi}{2}$, *i.e.*, voltage leads by $\frac{\pi}{2}$

29. The output current versus time curve of a rectifier is shown in the figure. The average value of output current in this case is



(A) 0

(B) $\dfrac{I_0}{2}$

(C) $\dfrac{2I_0}{\pi}$

(D) I_0

Ans. (C)

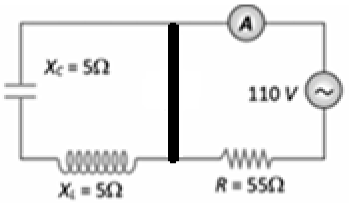
Sol.

$$I_{av} = \frac{\int_0^{T/2} i\,dt}{\int_0^{T/2} dt} = \frac{\int_0^{T/2} I_0 \sin(\omega t)dt}{T/2}$$

$$= \frac{2I_0}{T}\left[\frac{-\cos \omega t}{\omega}\right]_0^{T/2} = \frac{2I_0}{T}\left[-\frac{\cos\left(\frac{\omega T}{2}\right)}{\omega} + \frac{\cos 0°}{\omega}\right]$$

$$= \frac{2I_0}{\omega T}[-\cos\pi + \cos 0°] = \frac{2I_0}{2\pi}[1+1] = \frac{2I_0}{\pi}$$

30. The reading of ammeter in the circuit shown will be



(A) 2A

(B) 2.4A

(C) Zero

(D) 1.7A

Ans. (A)

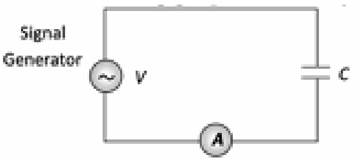
Sol. Given $X_L = X_C = 5\Omega$, this is the condition of resonance. So $V_L = V_C$, so net voltage across L and C combination will be zero

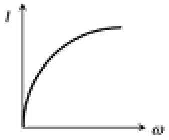
The ammeter measures the total current flowing through the series circuit.
Using Ohm's Law for AC circuits, the current (I) is given by:

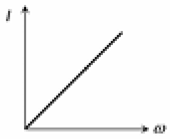
$$I = \frac{V}{Z}$$

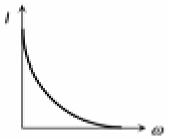
$$I = \frac{110\text{ V}}{55\Omega} = 2\text{ A}$$

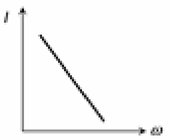
31. A constant voltage at different frequencies is applied across a capacitance C as shown in the figure. Which of the following graphs correctly depicts the variation of current with frequency



(A) 

(B) 

(C) 

(D) 

Ans. (B)

Sol.

For capacitive circuits $X_C = \frac{1}{\omega C}$

$$\therefore i = \frac{V}{X_C} = V\omega C \Rightarrow i \propto \omega$$

32. Average Power dissipated in an LCR series circuit connected to an a.c. source of emf E is

(A) $E^2R / \left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]$

(B) $\dfrac{E^2\sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}}{R}$

(C) $\dfrac{E^2\left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]}{R}$

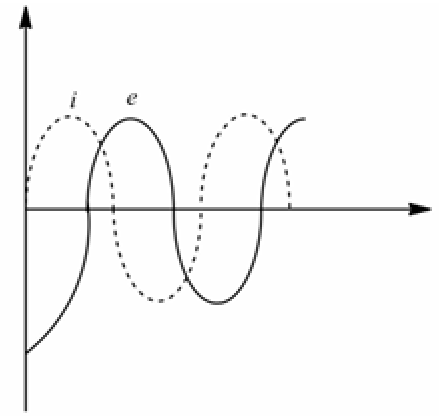
(D) $\sqrt{R^2+\left(L\omega-\frac{1}{C\omega}\right)^2}$

Ans. (A)

Sol. $P=E_{rms}i_{rms}\cos\phi=\frac{E^2R}{Z^2}=\frac{E^2R}{\left[R^2+\left(\omega L-\frac{1}{\omega C}\right)^2\right]}$

33.

When an AC source of emf $e=E_0\sin(100t)$ is connected across a circuit, the phase difference between the emf e and the current i in the circuit is observed to be $\frac{\pi}{4}$, as shown in the diagram. If the circuit consists possibly only of $R-C$ or $R-L$ or $L-C$ in series, find the relationship between the two elements



(A) $R=1\text{k}\Omega, C=10\mu\text{F}$

(B) $R=1\text{k}\Omega, C=1\mu\text{F}$

(C) $R=1\text{k}\Omega, L=10\text{H}$

(D) $R=1\text{k}\Omega, L=1\text{H}$

Ans. (A)

As the current i leads the emf e by $\frac{\pi}{4}$, it is an $R-C$ circuit

$\tan\phi=\frac{X_C}{R}$

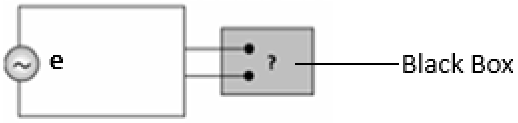
or $\tan\frac{\pi}{4}=\frac{\frac{1}{\omega C}}{R}$

$\therefore$ $\omega CR=1$

As $\omega=100\text{ rads}^{-1}$

Sol. The product of $C-R$ should be $\frac{1}{100}\text{s}^{-1}$.

34. Following figure shows an ac generator connected to a "black box" through a pair of terminals. The box contains possible R,L,C or their combination, whose elements and arrangements are not known to us. Measurements outside the box reveals t



$e = 75\sin(\sin \omega t)$ volt

$i = 1.5\sin\left(\omega t + 45^\circ\right)$ amp. The wrong statement is

(A) There must be a capacitor in the box

(B) There must be an inductor in the box

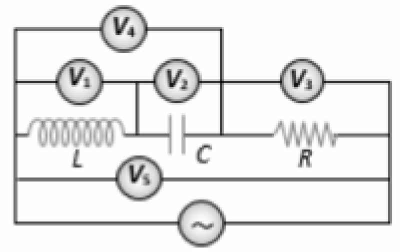
(C) There must be a resistance in the box

(D) The power factor is 0.707

Ans. (B)

Sol. Since voltage is lagging behind the current, so there must be no inductor in the box.

35. In the adjoining ac circuit the voltmeter whose reading will be zero at resonance is

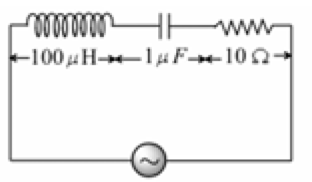


(A) V_1
(B) V_2
(C) V_3
(D) V_4

Ans. (D)

Sol. At resonance net voltage across L and C is zero

36. The following series L-C-R circuit, when driven by an e.m.f. source of angular frequency 70 kiloradians per second, the circuit effectively behaves like



(A) a) Purely resistive circuit

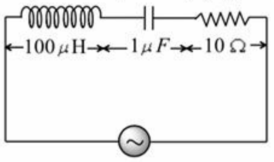
(B) Series R-L circuit

(C) Series R-C circuit

(D) Series L-C circuit with R=0

Ans. (C)

Impedance, $Z = \sqrt{(X_L \sim X_C)^2 + R^2}$



$$Z = \sqrt{\left(\omega L \sim \frac{1}{\omega C}\right)^2 + R^2}$$

Inductive reaction

$X_L = \omega L = 70 \times 10^3 \times 100 \times 10^{-6} = 7\Omega$

Capacitance reactance

$$X_C = \frac{1}{\omega C} = \frac{1}{70 \times 10^3 \times 1 \times 10^{-6}}$$
$$= \frac{100}{7} \quad [X_C > X_L]$$

Hence, circuit behaves like an R-C circuit

Sol.

37. A voltage of peak value 283 V and varying frequency is applied to a series L-C-R combination in which $R = 3\Omega, L = 25\text{mH}$ and $C = 400\mu\text{F}$ The frequency (in Hz)of the source at which maximum power is dissipated in the above, is

(A) 51.5

(B) 52.7

(C) 54.03

(D) 50.3

Ans. (D)

A series resonance circuit admits maximum current, as

$$P = i^2 R$$

So, power dissipated is maximum at resonance

So, frequency of the source at which maximum power is dissipated in the circuit is

$$v = \frac{1}{2\pi\sqrt{LC}}$$
$$= \frac{1}{2\times3.14\sqrt{25\times10^{-3}\times400\times10^{-6}}}$$
$$= \frac{1}{2\times3.14\sqrt{10^{-5}}} = 50.3\text{ Hz}$$

Sol.

38. In an AC circuit, V and I are given by $V = 150\sin(150t)$ volt and $I = 150\sin\left(150t + \frac{\pi}{3}\right)$ amp. The power dissipated in the circuit is

(A) Zero

(B) 5625 W

(C) 150 W

(D) 106 W

Ans. (B)

Sol.

$$\text{Power } P = \frac{1}{2} V_0 I_0 \cos\phi$$

$$= 0.5 \times 150 \times 150 \times \cos 60^\circ = \frac{22500}{4}$$

$$= 5625 \text{ W}$$

39. The coefficient of induction of a choke coil is 0.1 H and resistance is 12Ω. If it is connected to an alternating current source of frequency 60 Hz , then power factor will be

(A) 0.32

(B) 0.30

(C) 0.28

(D) 0.24

Ans. (B)

Sol.

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + \omega^2 L^2}}$$

$$= \frac{12}{\sqrt{(12)^2 + 4 \times \pi^2 \times (60)^2 \times (0.1)^2}} \Rightarrow \cos\phi$$

$$= 0.30$$

40. A bulb is rated at 100 V, 100 W, it can be treated as a resistor. Find out the inductance of an inductor (called choke coil) that should be connected in series with the bulb to operate the bulb at its rated power with the help of an ac source of 200 V and 50 Hz .

(A) $\frac{\pi}{\sqrt{3}}$ H

(B) $100H$

(C) $\frac{\sqrt{2}}{\pi}$ H

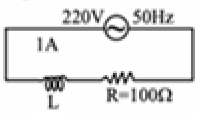
(D) $\frac{\sqrt{3}}{\pi}$ H

Ans. **(D)**

Sol.

From the rating of the bulb, the resistance of the bulb can be calculated.

$$R = \frac{V_{rms}^{\ 2}}{P} = 100\Omega$$



For the bulb to be operated at its rated value the rms current through it should be 1A

Also,

$$I_{rms} = \frac{V_{rms}}{Z} \therefore 1 = \frac{200}{\sqrt{100^2 + (2\pi 50 L)^2}} \Rightarrow L = \frac{\sqrt{3}}{\pi} \text{H}$$

41. The primary winding of a transformer has 200 turns and its secondary winding has 50 turns. If the current in the secondary winding is 40 A , the current in the primary is

(A) 10 A
(B) 80 A
(C) 160 A
(D) 800 A

Ans. (A)

Sol. $i_P = \frac{n_s}{n_P} i_s = \frac{50}{200} \times 40 = 10\,\text{A}$

42. In an ideal transformer, the voltage is stepped down from 11 kV to 220 V . If the primary current be 100 A , the current in the secondary should be

(a) 5 kA
(b) 1 kA
(c) 0.5 kA
(d) 0.1 kA

Ans. **(A)**

Sol. $i_\Delta = \frac{E_p l_p}{E_\lambda} = \frac{11000 \times 100}{200} = 5\text{kA}$

43. A resistor R, an inductor L and a capacitor C are connected in series to an oscillator of frequency n, if the resonant frequency is n_r, then the current lags behind voltage, when

(A) n=0
(B) $n<n_r$
(C) $n=n_r$
(D) $n>n_r$

Ans. **(D)**

Sol. The current will lag behind the voltage when reactance of inductance is more than the reactance of condenser.
Thus, $\omega L > \frac{1}{\omega C}$ or $\omega > \frac{1}{\sqrt{LC}}$
or $n > \frac{1}{2\pi\sqrt{LC}}$ or $n > n_r$ where n_r = resonant frequency

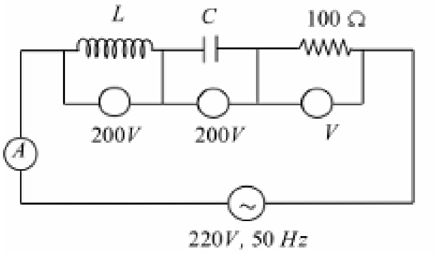
44. The reactance of a coil indicator when used in the domestic ac power supply (220 volts, 50 cycles per second) is 50 ohms . The inductance of the coil is nearly

(A) 2.2 henry
(B) 0.22 henry
(C) 1.6 henry
(D) 0.16 henry

Ans. **(D)**

Sol. $X_L = 2\pi v L \Rightarrow L = \frac{X_L}{2\pi v} = \frac{50}{2 \times 3.14 \times 50} = 0.16\text{H}$

45. The readings of ammeter and voltmeter in the following circuit are respectively



(A) 2A, 200 V

(B) 1.5A ,100V

(C) 2.7A,220V

(D) 2.2A,220V

Ans. **(d)**

Sol.

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$\because V_R = V \quad \because V_L = V_C$$

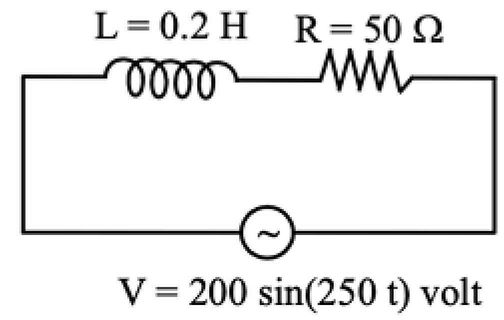
$$\therefore \text{ Reading of voltmeter} = 220V$$

$$\text{Reading of ammeter } I_{rms} = \frac{E_{rms}}{Z}$$

$$= \frac{220}{100} = 2.2A$$

SECTION-B

46. In the given circuit the average power developed is 100xn Watts. Find the value of n.



Ans. (2.00)

Sol.

$$P = V_{rms} I_{rms} \cos\phi$$

$$P = V_{rms} \frac{V_{rms}}{Z} \frac{R}{Z}$$

$$= \frac{V_{rms}^2}{Z^2} R$$

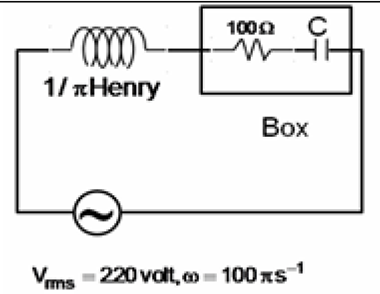
$$Z = \sqrt{R^2 + (L\omega)^2} = \sqrt{(50)^2 + (0.2 \times 250)^2}$$

$$= \sqrt{2500 + (50)^2}$$

$$=50\sqrt{2}$$

$$\therefore P = \left(\frac{200}{\sqrt{2}}\right)^2 \times \frac{50}{50\sqrt{2}} \times \frac{1}{50\sqrt{2}} = 200 \text{ watt}$$

47. In the circuit, as shown in the figure, if the value of R.M.S current is 2.2 ampere, the power factor of the box is $\sqrt{\frac{1}{m}}$, Find m.



Ans. (2)

Sol.

$$Z = \frac{V_{rms}}{I_{rms}} = \frac{220}{2.2} = 100$$

$$\because R = Z \Rightarrow \omega L = \frac{1}{\omega C}$$

$$\Rightarrow \omega L = \frac{1}{\pi} \times 100\pi = 100\,\Omega$$

$$\text{power factor} = \cos 45^\circ = \frac{1}{\sqrt{2}}$$

$$\Rightarrow m = 2$$

48. In a series L-C-R circuit, resistance R=10 Ω and the impedance, $Z = 10\Omega$. The phase difference between the current and the voltage is $15n^\circ$. Evaluate n.

Ans. (0)

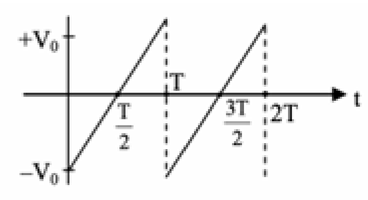
Sol. $\cos\phi = \frac{R}{z} = 1; \phi = 0^\circ$

49. In an L-R circuit $(L = 35\text{mH and } R = 11\Omega)$ and, a variable emf source $(V = V_0 \sin \omega t)$ of $V_{rms} = 220$ V and frequency 50 Hz is applied. The current amplitude in the circuit is 10n amp. Find n . $(\pi = 22/7)$

Ans. (2)

Sol. Conceptual

50. rms value of the saw-tooth voltage of peak value V_0 as shown in figure is $\frac{V_0}{\sqrt{n}}$



Find n.

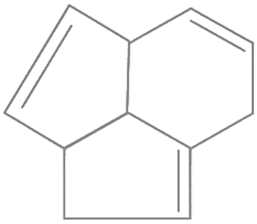
Ans. (3)

Sol. $$V_{rms} = \sqrt{\frac{\int_0^T v^2 dt}{T}} = \sqrt{\frac{\int_0^T \left(-v_0 + \frac{2v_0 t}{T}\right)^2 dt}{T}}$$

PART-C: CHEMISTRY

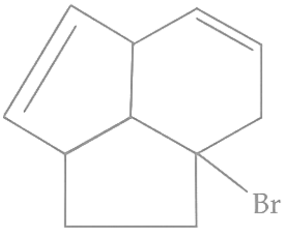
SECTION-A

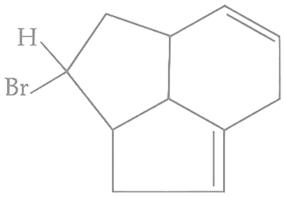
51. Consider the following molecule (X).

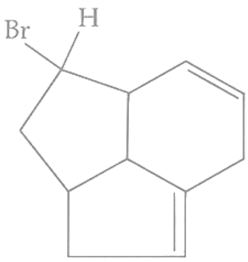
The structure of X is 

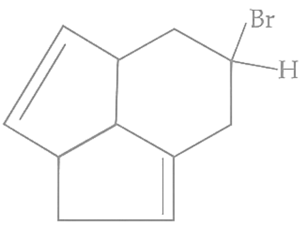
(X)

The major product formed when the given molecule (X) is treated with HBr (1eq) is :

(A) 

(B) 

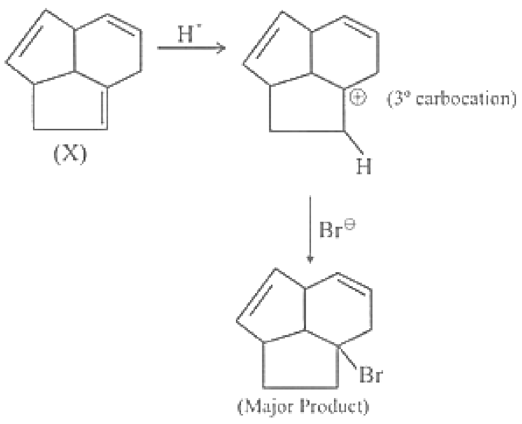
(C) 

(D) 

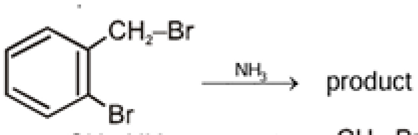
Ans. (A)

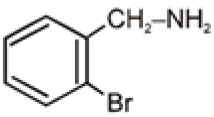
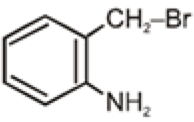
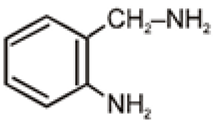
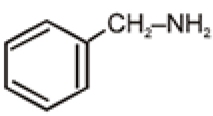
Among the given options, the major product decided by stability of carbocation formed in intermediate.

Sol.



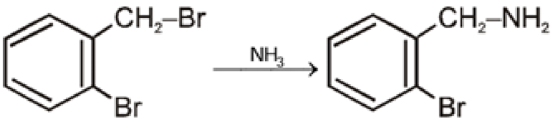
52. What is the major product obtained in the following reaction?



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

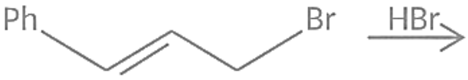
Ans. (A)

Sol.

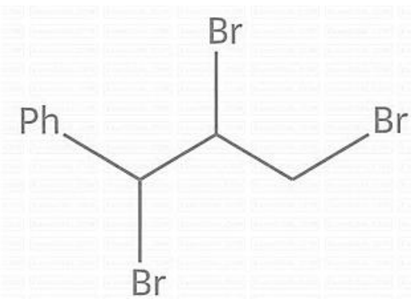


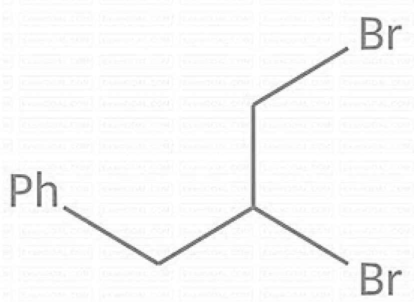
Because aromatic halides do not give S_N reaction in normal conditions.

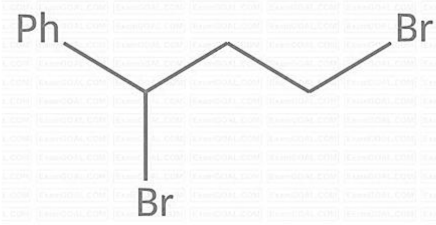
53. The major product (P) in the reaction

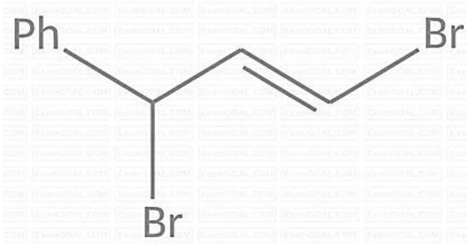


?(P) [Ph is – C_6H_5] is

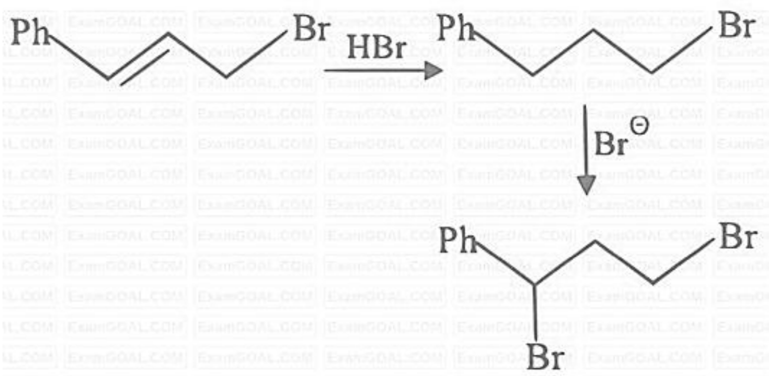
(A) 

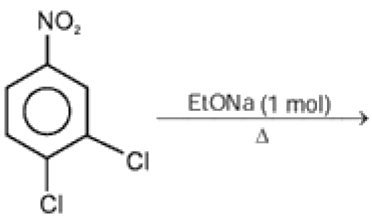
(B) 

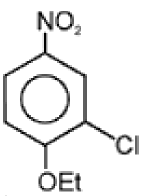
(C) 

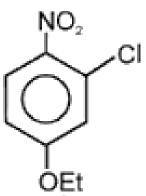
(D) 

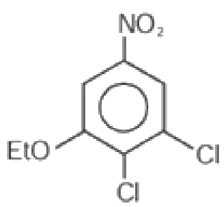
Ans. (C)

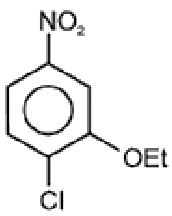
Sol. 

54.  The product is :

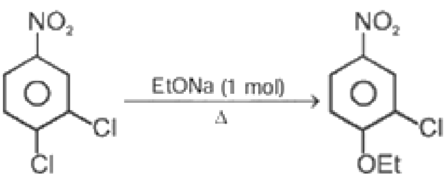
(A) 

(B) 

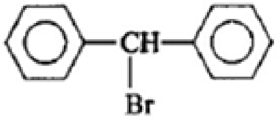
(C) 

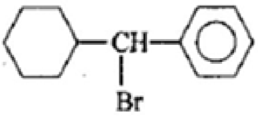
(D) 

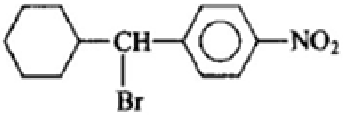
Ans. (A)

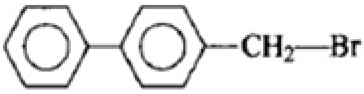
Sol.  [– M effect of $-NO_2$ group at para position]

55. The rate of S_N1 reaction is fastest with:

(A) 

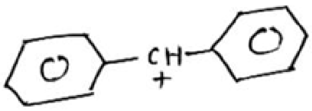
(B) 

(C) 

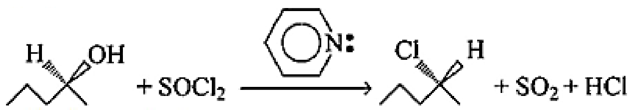
(D) 

Ans. (A)

Sol. Due to stable carbocation



56. The reaction



proceed by the mechanism :

(A) S_N1

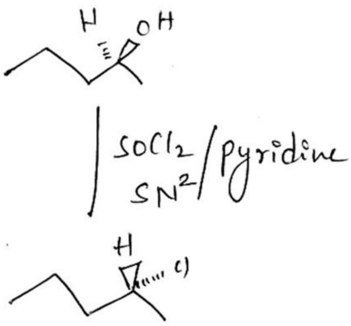
(B) S_N2

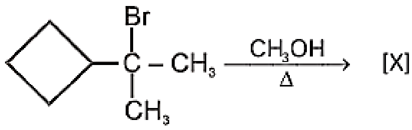
(C) S_E

(D) S_Ni

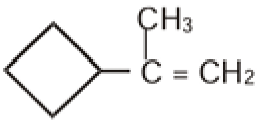
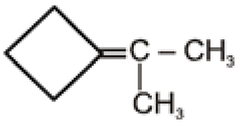
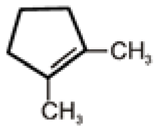
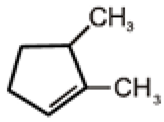
Ans. (B)

Sol.

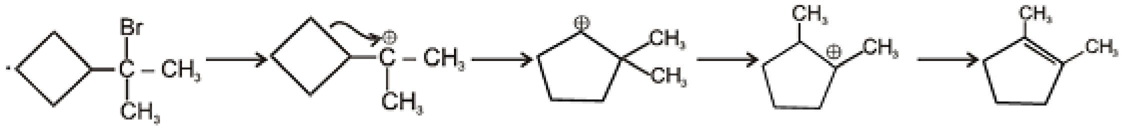


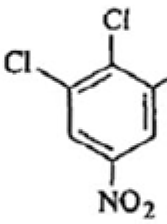
57. In the given reaction, 

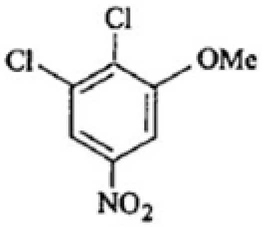
[X] as the major product among the elimination products is :

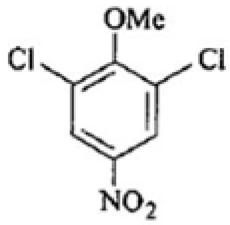
(A)  (B)  (C)  (D) 

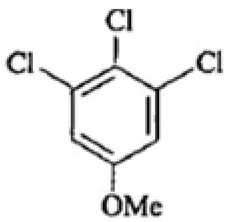
Ans. (C)

Sol. 

58.  + CH_3ONa (1 mole) $\longrightarrow$ P (major); P is :

(A) 

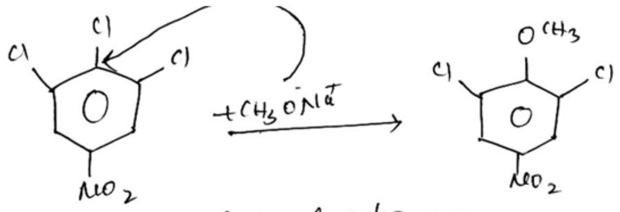
(B) 

(C) 

(D) None of these

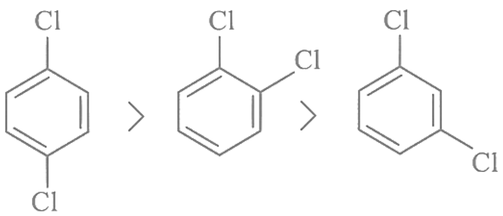
Ans. (B)

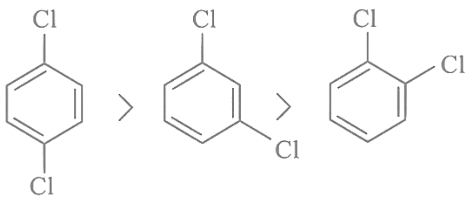
Sol.

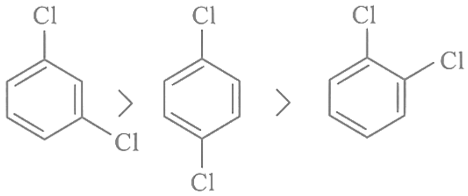


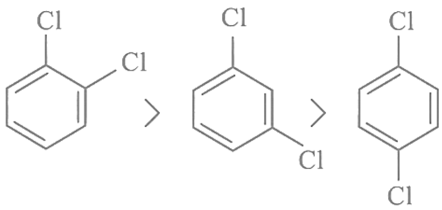
NO_2 group effect at ortho & para position

59. The correct order of melting point of dichlorobenzenes is

(A) 

(B) 

(C) 

(D) 

Ans. (A)

Sol. Out of o, m, p-dichlorobenzene para isomer has maximum melting point due to symmetrical nature.

60. The product A and B in the following reactions, respectively are

$$A \xleftrightarrow{Ag-NO_2} CH_3 - CH_2 - CH_2 - Br \xrightarrow{AgCN} B$$

(A) $CH_3 - CH_2 - CH_2 - ONO, CH_3 - CH_2 - CH_2 - CN$

(B) $CH_3 - CH_2 - CH_2 - NO_2, CH_3 - CH_2 - CH_2 - CN$

(C) $CH_3 - CH_2 - CH_2 - ONO, CH_3 - CH_2 - CH_2 - NC$

(D) $CH_3 - CH_2 - CH_2 - NO_2, CH_3 - CH_2 - CH_2 - NC$

Ans. (D)

Sol.

$$\underset{(A)}{CH_3 - CH_2 - CH_2 - NO_2} \xleftarrow{Ag-NO_2} CH_3 - CH_2 - CH_2 - Br \xrightarrow{AgCN} \underset{(B)}{CH_3 - CH_2 - CH_2 - NC}$$

61. Which among the following reactions is used for the preparation of alkyl fluorides?

(A) Finkelstein reaction

(B) Swartz reaction

(C) Fitting reaction

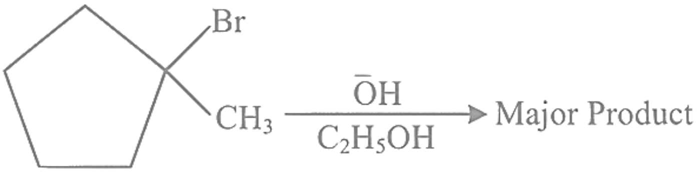
(D) Wurtz reaction

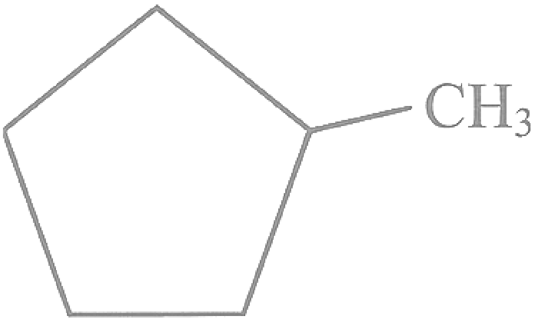
Ans. (B)

Sol. Alkyl fluorides are prepared by heating alkyl chlorides or bromides with metal fluorides such as $AgF, Hg_2F_2, AsF_3, SbF_3$, etc. This reaction is known as Swartz reaction.

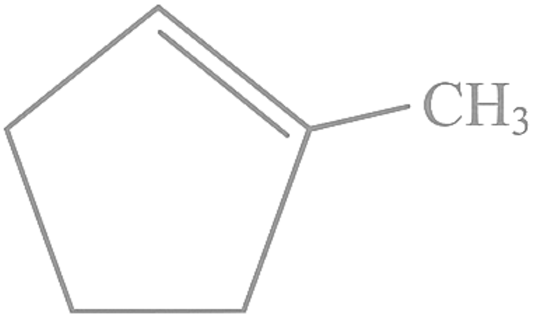
$$R-Cl+AgF \longrightarrow R-F+AgCl\downarrow$$

62. Identify the major product in the following reaction

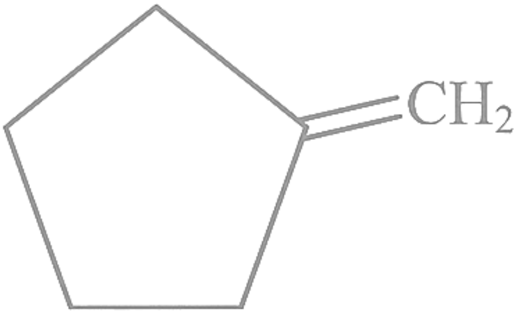




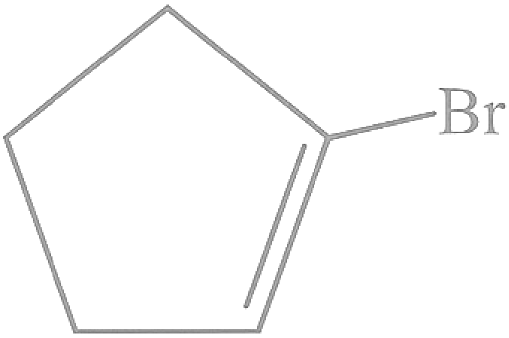
(A)



(B)



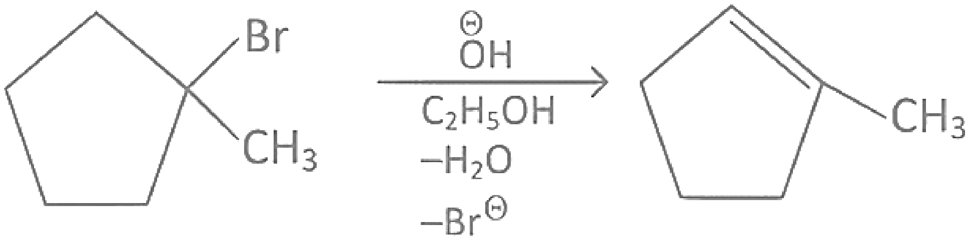
(C)



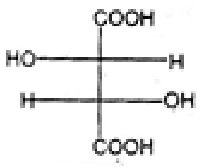
(D)

Ans. (B)

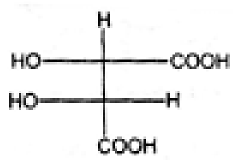
Sol.



63.



has optical rotation $+12^{\circ}$, so optical rotation of



will be

(A) +12

(B) -12

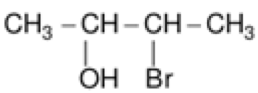
(C) 0

(D) Can not be predicted

Ans. (C)

Sol. Both are enantiomer of each other. So optical rotation will be -12

64. Total number of stereoisomers of compound is:



(A) 2

(B) 4

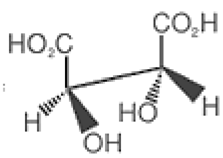
(C) 6

(D) 8

Ans. (B)

Sol. Unsymmetrical compound with 2 chiral centres has 2^2=4 stereoisomers.

65. The absolute configuration of



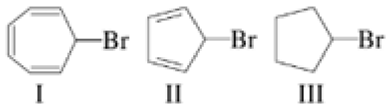
is

(A) R, R
(B) R, S
(C) S, R
(D) S, S

Ans. (A)

Sol. The absolute configuration is (R, R)
(using priority rules to get the absolute configuration)

66. Among the compounds



The order of decreasing S_N1 reactivity is
(A) I > II > III
(B) I > III > II
(C) II > III > I
(D) III > I > II

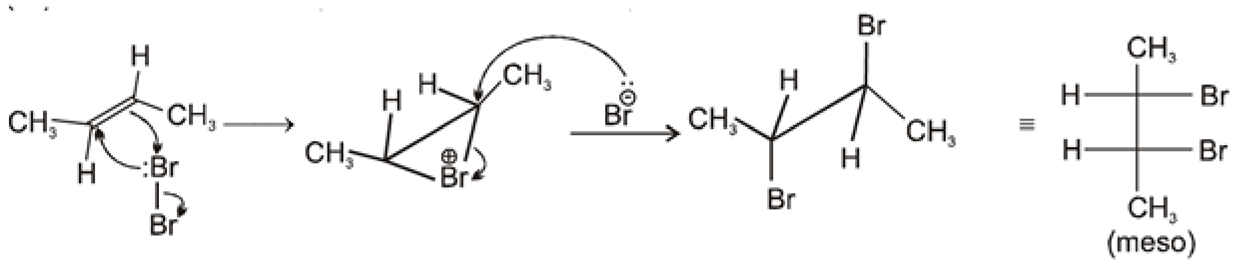
Ans. (B)

Sol. Rate of SN_1 reaction $\propto$ stability of carbocation

67. The number of stereoisomers obtained by bromination of trans-2-butene is
(A) 1
(B) 2
(C) 3
(D) 4

Ans. (A)

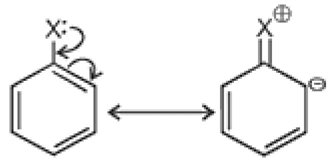
Sol.



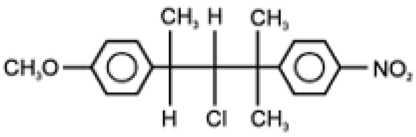
68. Aryl halides are less reactive towards nucleophilic substitution reactions as compared to alkyl halides due to
(A) The formation of less stable carbanion
(B) Longer carbon halogen bond
(C) The inductive effect
(D) sp^2 -hybridized carbon attached to the halogen

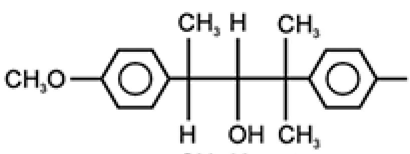
Ans. (D)

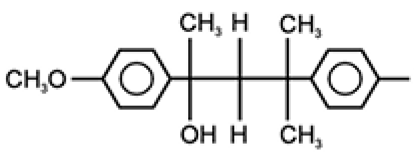
Sol. In aryl halides the C-X bond has partial double bond character due to resonance so the cleavage of C- X bond becomes difficult.

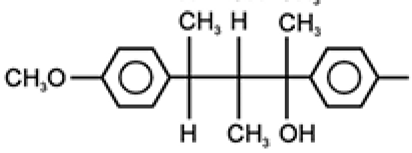


69.

Compound (X)  is reacted with aqueous acetone it gives following products.

 (K)

 (L)

 (M)

(A) K, L

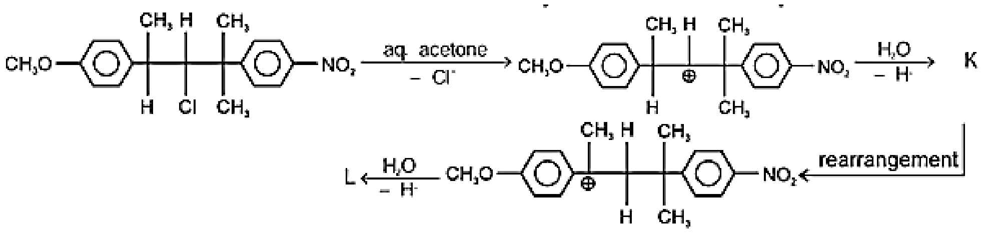
(B) K, M

(C) L only

(D) M only

Ans. (A)

Sol.



70. Which of the following will have meso-isomer also?

(A) A 2-chlorobutane

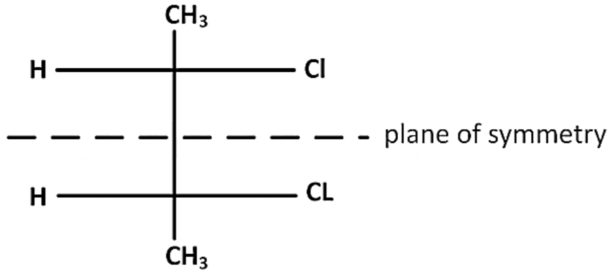
(B) 2-hydroxyopanoic acid

(C) 2,3-dichloropentane

(D) 2-3-dichlorobutane

Ans. (A)

Sol. For meso compounds a compound should have atleast two chiral centers and have elements of symmetry.



Meso 2, 3 dichlorobutane

SECTION-B

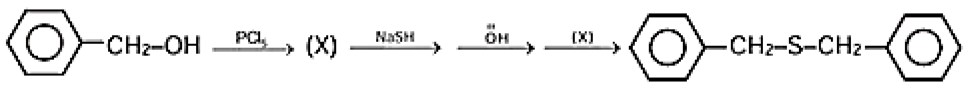
71. Pure cholesterol has a specific rotation of −32. A sample of cholesterol prepared in the lab has a specific rotation of −8. The enantiomeric excess of the sample of chloresterol is x%. x is :

Ans. 25.00

Sol.

$$\text{Enatiomeric excess} = \frac{[\alpha]\ \text{mixture}}{[\alpha]\ \text{pure enantiomer}} \times 100 = \frac{-8}{-32} \times 100 = 25\%$$

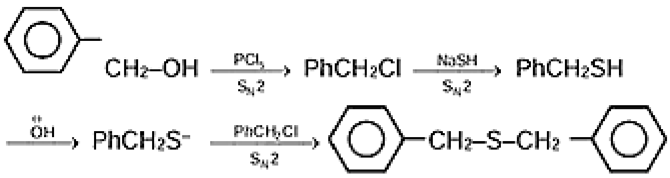
72.



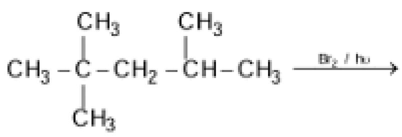
The number of times where S_N2 reaction takes place in above equation reaction sequence is

Ans. 3

Sol.

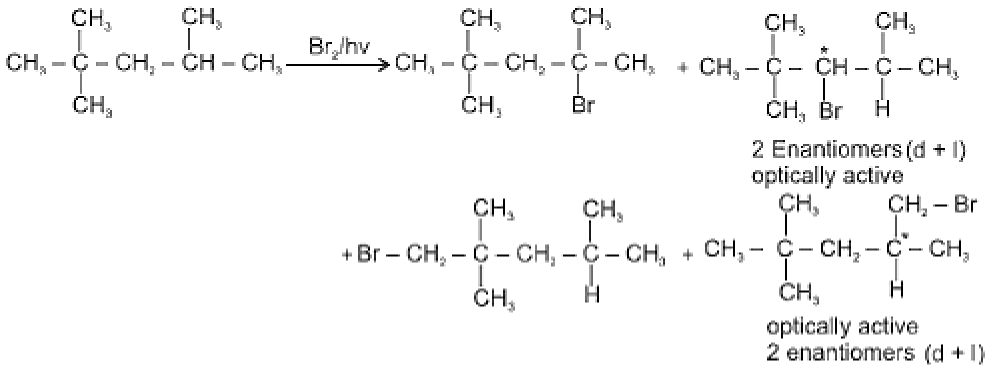


73. For the given reaction how many products are optically active (all isomers) :

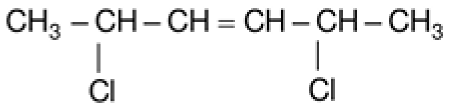


Ans. (6)

Sol.



74. Total number of optically active stereoisomers of

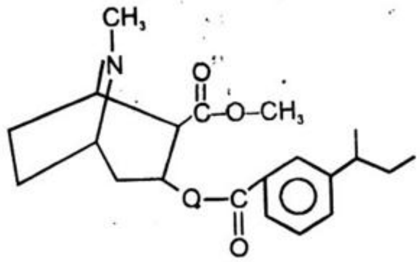


are:

Ans. (4.00)

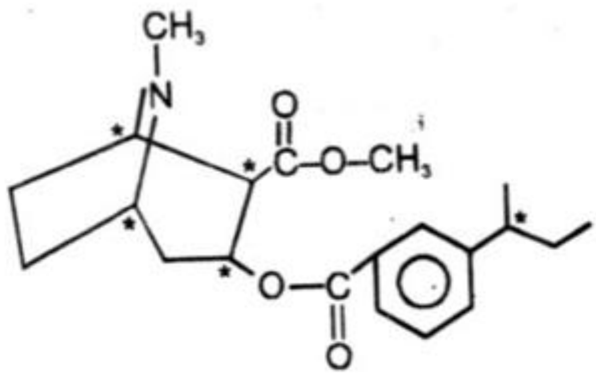
Sol. Number of optically active stereoisomers =4 and total stereoisomers =6.

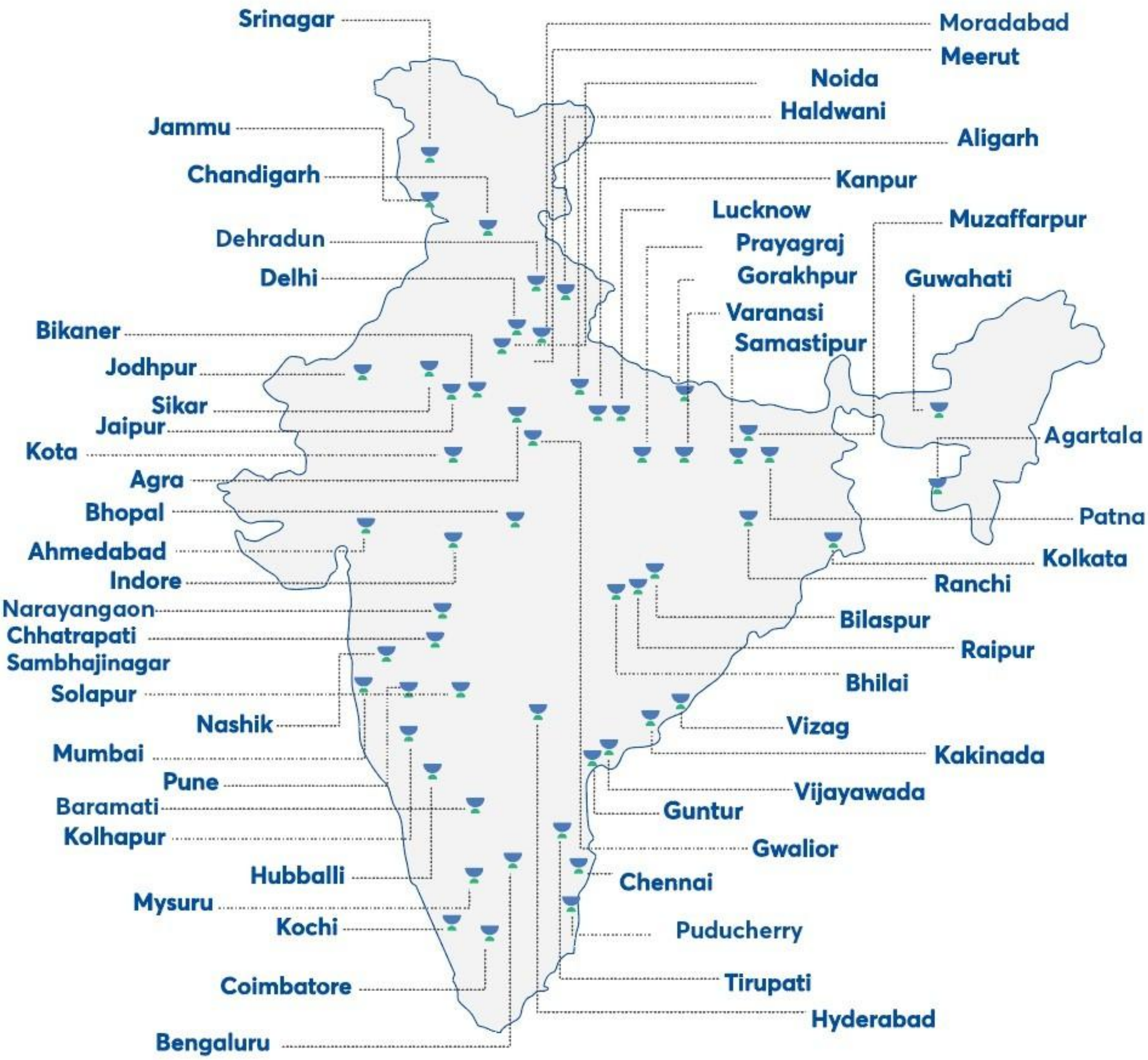
75. Cocaine is hallucinogen used widely. How many chiral carbon does it have.



Ans. 5.00

Sol.




Srinagar
Moradabad
Meerut
Noida
Haldwani
Jammu
Aligarh
Chandigarh
Kanpur
Lucknow
Muzaffarpur
Dehradun
Prayagraj
Gorakhpur
Delhi
Guwahati
Varanasi
Bikaner
Samastipur
Jodhpur
Sikar
Jaipur
Agartala
Kota
Agra
Patna
Bhopal
Ahmedabad
Kolkata
Indore
Ranchi
Narayangaon
Bilaspur
Chhatrapati
Sambhajinagar
Raipur
Solapur
Bhilai
Nashik
Vizag
Mumbai
Kakinada
Pune
Vijayawada
Baramati
Guntur
Kolhapur
Gwalior
Hubballi
Chennai
Mysuru
Kochi
Puducherry
Coimbatore
Tirupati
Hyderabad
Bengaluru