JEE ADVANCED-2026

PAPER-1

(CHEMISTRY)

SECTION-1 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +3 If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : −1 In all other cases.

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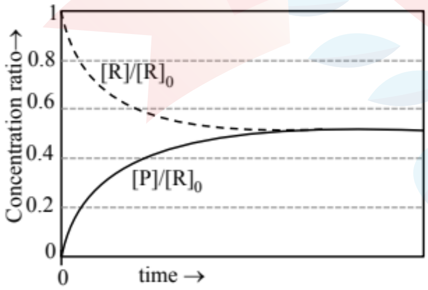
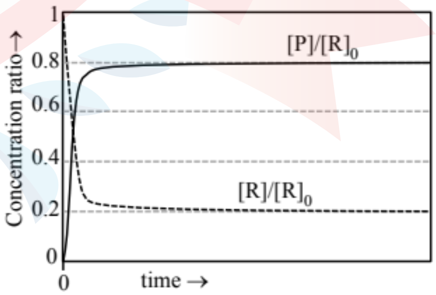
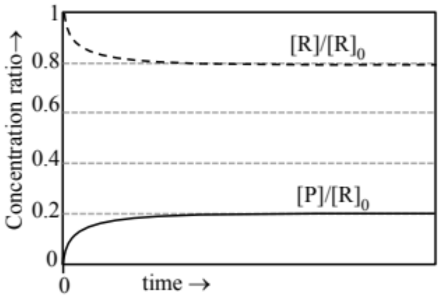
1. An ideal gas (0.5 mol), initially at 2 bar pressure, is compressed at a constant temperature of 600 K in two steps : first against a constant external pressure of P bar ($2 < P < 8$), and then against constant external pressure of 8 bar. At each step, the compression is stopped only when the pressure of the gas becomes equal to the external pressure. The total work done on the gas in these steps is W. Considering all possible values of P ($2 < P < 8$) and taking the gas constant as R (in $J\ K^{-1}\ mol^{-1}$), the minimum value of $|W|$ (in J) is

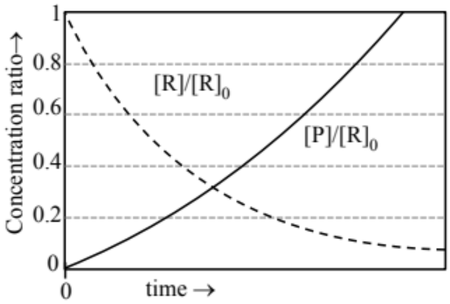
(A) 207 R (B) 600 R (C) 630 R (D) 900 R

2. For a reversible reaction $\mathbf{R} \rightleftharpoons \mathbf{P}$, at constant temperature, both the forward and the backward reactions are first order elementary reaction with rate constant k_f and k_b, respectively. At time zero, the concentration of **R** is $[R]_0$ and the concentration of **P** is zero. At any given time **[R]** and **[P]** are the concentration of **R** and **P**, respectively. If $k_b = 4k_f$, the correct graphical representation of the reaction is

(A)


(B)


(C)


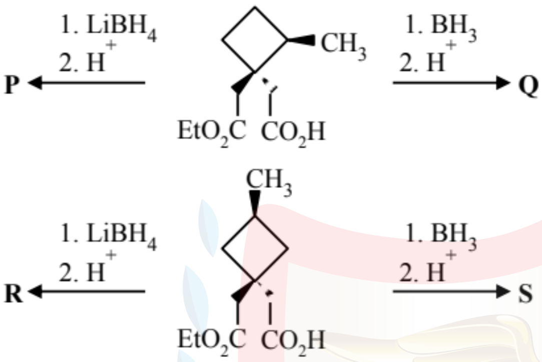
(D)


3. The correct order of dipole moments for the given species is

(A) $BF_3 = NH_4^+ < NF_3 < NH_3$ (B) $BF_3 < NH_4^+ < NF_3 < NH_3$

(C) $NH_4^+ < BF_3 < NH_3 < NF_3$ (D) $BF_3 < NH_4^+ < NH_3 < NF_3$

4. Considering $LiBH_4$ reduces an ester group to the corresponding alcohol and does not reduce a carboxylic acid group, the correct statement about the major products **P, Q R** and **S** is



(A) **P** & **Q** are identical, and **R** & **S** are diastereomers.

(B) **P** & **Q** are diastereomers, and **R** & **S** are identical.

(C) **P** & **Q** are diastereomers, and **R** & **S** are diastereomers.

(D) **P** & **Q** are identical, and **R** & **S** are identical.

SECTION-2 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks	: +4	**ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks	: +3	If all the four options are correct but **ONLY** three options are chosen;
Partial Marks	: +2	If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
Partial Marks	: +1	If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then
choosing ONLY (A), (B) and (D) will get +4 marks;
choosing ONLY (A) and (B) will get +2 marks;
choosing ONLY (A) and (D) will get +2 marks;
choosing ONLY (B) and (D) will get +2 marks;
choosing ONLY (A) will get +1 marks;
choosing ONLY (B) will get +1 marks;
choosing ONLY (D) will get +1 marks;
choosing no option (i.e. the question is unanswered) will get 0 marks; and
choosing any other combination of options will get –1 marks.

5. The 2s and the 2p orbital energies of hydrogen atom are $E_{2s}(H)$ and $E_{2p}(H)$, respectively. The 2s and the 2p orbital energies of lithium atom are $E_{2s}(Li)$ and $E_{2p}(Li)$, respectively. The correct option (s) about the orbital energies is (are)

(A) $E_{2s}(Li) < E_{2p}(Li)$ (B) $E_{2s}(H) = E_{2p}(H)$ (C) $E_{2p}(H) < E_{2s}(Li)$ (D) $E_{2s}(H) > E_{2s}(Li)$

6. Correct statement(s) about the compounds **X, Y** and **Z** is (are)

$$MnO_2 + \text{Conc. HCl} \longrightarrow MnCl_2 + \underset{\text{(greenish yellow gas)}}{\mathbf{X}} + H_2O$$

$$NH_3 + \underset{\text{(excess)}}{\mathbf{X}} \longrightarrow \mathbf{Y} +$$

$$\mathbf{X} + \underset{\text{(excess)}}{F_2} \xrightarrow{573K} \mathbf{Z}$$

(A) **X** is used for sterlizing drinking water.

(B) **Y** has a planar structure.

(C) **Z** is used in the enrichment of ^{235}U.

(D) **Y** is a stronger Lewis base than ammonia.

7. Reaction of PtF_6 with oxygen (O_2) gas results in the formation of an ionic compound, $\mathbf{X}^+\mathbf{Y}^-$.

Correct statement(s) is (are)

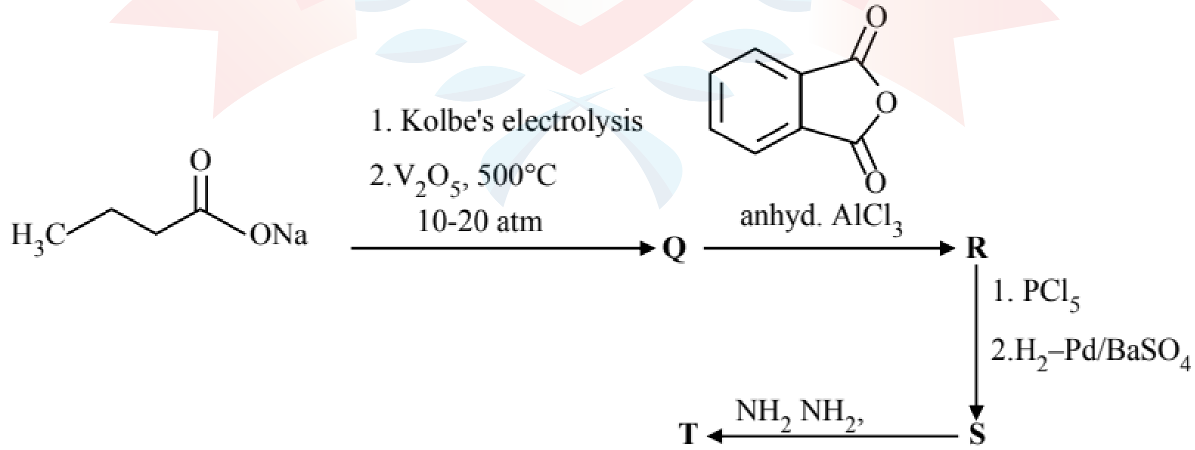
(A) The bond order of $\mathbf{X}^+$ is 1.5.

(B) Valence **d**-orbitals of the metal ion in $\mathbf{X}^+\mathbf{Y}^-$ has 5 electrons.

(C) PtF_6 acts as an oxidant in this reaction.

(D) PtF_6 acts as a fluorinating agent in this reaction.

8. In the following reaction sequence **Q, R, S** and **T** are the major products.



The correct statement(s) about **Q, R, S** and **T** is (are)

(A) **S** on warming with ammoniacal $AgNO_3$ results in the formation of silver mirror.

(B) **Q** on treatment with Cl_2 (excess)/ UV gives gammaxane.

(C) **T** is a heterocylic compound.

(D) **R** on acid catalyzed intermolecular cyclization followed by treatment with Zn-Hg/HCl gives 9, 10-dihydroxyanthracene.

SECTION-3 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value corresponding to the answer using in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**
  Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;
  Zero Marks : 0 In all other cases.

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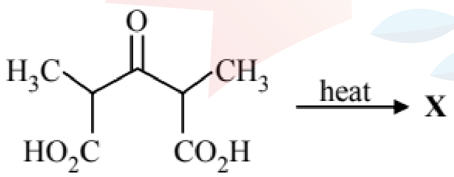
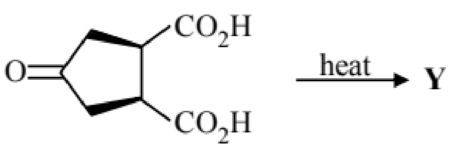
9. The cylinders, both fitted with frictionless pistons, are filled with mixtures of He and Ar gases. In the first cylinder, the masses of He and Ar are m_1 and m_2, respectively. In the second cylinder, the masses of He and Ar are m_2 and m_1 , respectively the molar mass of Ar is 10 times the molar mass of He. The external pressure applied by the piston on the first cylinder needs to be 5 times that on the second cylinder so that the volume of the gas mixtures in both the cylinders are equal at the same temperature. Assuming He and Ar behaves like ideal gases, the value of (m_1/m_2) is _____.

10. The total number of all possible isomers for the square planar complex with formula $K[M(NCS)(NO_2)(gly)]$ is ______
(M = metal ion and gly = $NH_2CH_2COO^-$)

11. The sum of total number of carbonyl groups (>C=O) present in the major products **X** and **Y** in the following reactions is _______.





12. Treatment of buta-1,3-diyne with $NaNH_2$ (2 equivalents), followed by reaction with excess of trans-CH_3–CH=CH–CH_2-Br gives **X** as the major product. The maximum number of carbon atoms that are collinear (in a straight line) in **X** is ____.

SECTION-4 : (Maximum Marks : 16)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists : **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 **ONLY** if the option corresponding to the correct combination is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –1 In all other cases.

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13. **List-I** contains various physical/chemical processes, and **List-II** contains combinations of changes in enthalpy (ΔH) and entropy (ΔS). Match each entry in **List-I** to appropriate entry in **List-II**, and choose the correct option.

List-I		**List-II**	
(P)	Physisorption	(1)	$\Delta H > 0$ and $\Delta S > 0$
(Q)	Diamond $\rightarrow$ Graphite	(2)	$\Delta H < 0$ and $\Delta S < 0$
(R)	Denuturation of protein	(3)	$\Delta H < 0$ and $\Delta S = 0$
(S)	Propene $\rightarrow$ Cyclopropane	(4)	$\Delta H > 0$ and $\Delta S < 0$
		(5)	$\Delta H < 0$ and $\Delta S > 0$

(A) P $\rightarrow$ 2; Q $\rightarrow$ 3; R $\rightarrow$ 5; S $\rightarrow$ 4

(B) P $\rightarrow$ 4; Q $\rightarrow$ 3; R $\rightarrow$ 5; S $\rightarrow$ 1

(C) P $\rightarrow$ 2; Q $\rightarrow$ 5; R $\rightarrow$ 1; S $\rightarrow$ 4

(D) P $\rightarrow$ 2; Q $\rightarrow$ 5; R $\rightarrow$ 1; S $\rightarrow$ 3

14. Consider the following species :

$SOCl_2$, $XeOF_4$, ClF_3, ClF_5, XeF_5^+, SO_3^{2-}, XeF_3^+, SF_4

List-I contains different molecular shapes and **List-II** contains total number of species with the same molecular shapes from the given species. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

List-I		**List-II**	
(P)	See-saw	(1)	One
(Q)	T-Shaped	(2)	two
(R)	Trigonal Planar	(3)	three
(S)	Square Pyramidal	(4)	four
		(5)	zero

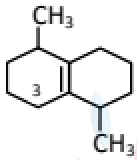
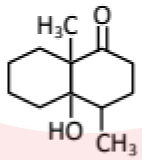
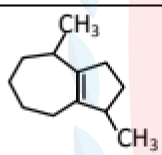
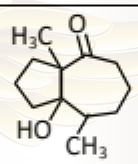
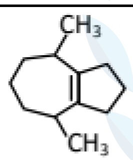
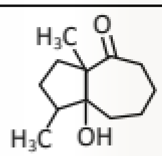
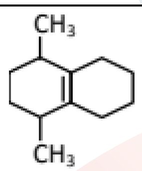
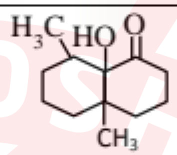
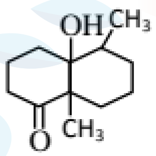
(A) P → 1; Q → 2; R → 5; S → 3

(B) P → 5; Q → 4; R → 2; S → 3

(C) P → 3; Q → 2; R → 1; S → 4

(D) P → 1; Q → 3; R → 5; S → 4

15. The **List-II** contains products obtained from the reaction of compounds in **List-I** with $O_3/Zn\text{-}H_2O$ followed by cyclization (via more stable enolate) in the presence of aqueous NaOH. Match each entry in **List-I** with appropriate entry in **List-II** and choose the correct option.

List-I		List-II	
(P)		(1)	
(Q)		(2)	
(R)		(3)	
(S)		(4)	
		(5)	

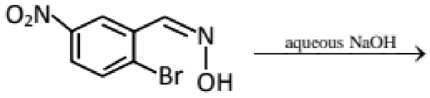
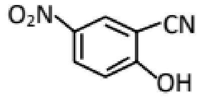
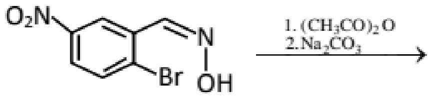
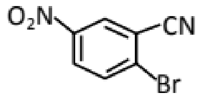
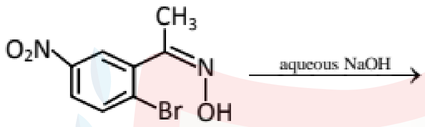
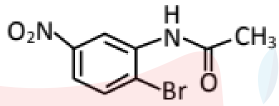
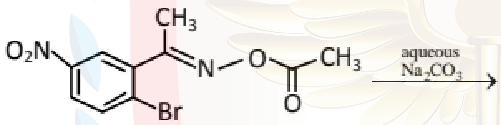
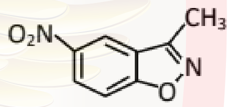
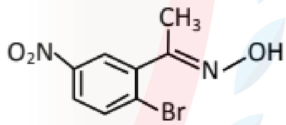
(A) P → 2; Q → 4; R → 1; S → 3

(B) P → 3; Q → 4; R → 5; S → 2

(C) P → 2; Q → 1; R → 5; S → 3

(D) P → 3; Q → 5; R → 4; S → 2

16. Match the major products obtained in the reactions given in **List-I** with the corresponding structures in **List-II** and choose the correct option.

List-I		List-II	
(P)		(1)	
(Q)		(2)	
(R)		(3)	
(S)		(4)	
		(5)	

(A) P → 2; Q → 1; R → 5; S → 4

(B) P → 1; Q → 2; R → 4; S → 5

(C) P → 1; Q → 2; R → 3; S → 4

(D) P → 2; Q → 1; R → 3; S → 5

(MATHEMATICS)

SECTION-1 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks	: +3	If **ONLY** the correct option is chosen;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

1. Consider the function $f : (0, \infty) \to (-\infty, \infty)$ given by

$f(x) = \sqrt{x} \log_e(x) - x + 1$

Then which one of the following statements is TRUE ?

(A) The derivative of the function f is decreasing in the interval (0, 1)

(B) The function f has a local maximum at some point $a \in (0, \infty)$

(C) The function f has a local minimum at some point $b \in (0, \infty)$

(D) The function f has NEITHER a point of local maximum NOR a point of local minimum in the interval $(0, \infty)$

2. Let P be the point on the parabola $y = x^2$ such that the slope of the tangent to the parabola at the point P is 4. Let Q be the point in the first quadrant lying on the circle $x^2 + y^2 = 2$ such that the slope of the tangent to the circle at the point Q is –1. Let R be the point in the first quadrant lying on the ellipse $x^2 + 4y^2 = 8$ such that the slope of the tangent to the ellipse at the point R is $-\frac{1}{2}$. Then the radius of the circle passing through the points P, Q and R is

(A) $\sqrt{10}$ (B) $\sqrt{5}$ (C) $\sqrt{\frac{5}{2}}$ (D) $2\sqrt{5}$

3. Which one of the following matrices can be obtained by performing elementary row transformations on the 3 × 3 identity matrix ?

(A) $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ (B) $\begin{bmatrix} 1 & 1 & 1 \\ 2 & 3 & 4 \\ 1 & 2 & 1 \end{bmatrix}$ (C) $\begin{bmatrix} 1 & 1 & 1 \\ 2 & 3 & 4 \\ 2 & 5 & 8 \end{bmatrix}$ (D) $\begin{bmatrix} 1 & 1 & 1 \\ -1 & 1 & 2 \\ 0 & 2 & 3 \end{bmatrix}$

4. Considering only the principal values of the inverse trigonometric functions, the value of

$$\cot^{-1}(\cot(-11)) + 10 \sin\left(2\cos^{-1}\left(\frac{1}{\sqrt{2}}\right)\right) + 10 \sin(2\tan^{-1}(2))$$

is

(A) $3\pi + 7$ (B) 7

(C) $4\pi + 7$ (D) $3\pi - 5$

SECTION-2 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 **ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks : +3 If all the four options are correct but **ONLY** three options are chosen;
Partial Marks : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
Partial Marks : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : −1 In all other cases.

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5. Suppose that Box I contains 6 red balls and 9 green balls, and Box II contains 8 red balls and 12 green balls. All the balls of Box I and Box II are mixed together and a ball is chosen at random from them. Let E_1 be the event that the ball chosen belonged to Box I and let E_2 be the event that the ball chosen belonged to Box II. Let F_1 be the event that the ball chosen is red and let F_2 be the event that the ball chosen is green.

Then which of the following statements is (are) TRUE ?

(A) The events E_1 and F_1 are independent

(B) The events E_2 and F_2 are dependent

(C) The conditional probability $P(F_1| E_1)$ is equal to the conditional probability $P(F_1| E_2)$

(D) The conditional probability $P(F_1| E_1)$ is greater than the conditional probability $P(F_2| E_2)$

6. Let P be the plane such that it contains the straight line $\frac{x-1}{2}=\frac{y-3}{3}=\frac{z+2}{1}$ and is perpendicular to the plane $x + 2y + 3z = 4$. Let P_1 be the plane which passes through the point (4, 2, 2) and is parallel to P.

Then which of the following statements is (are) TRUE ?

(A) The equation of the plane P is $7x - 5y + z = -10$

(B) The distance between the planes P and P_1 is 30

(C) The distance of the plane P from the origin is $2\sqrt{3}$

(D) The acute angle between the plane P and the plane $2x + 2y + z = 3$ is $\cos^{-1}\left(\frac{1}{3\sqrt{3}}\right)$

7. Let $\mathbb{R}$ denote the set of all real numbers. Let $f : \mathbb{R} \to \mathbb{R}$ be an arbitrary function and let $g : \mathbb{R} \to \mathbb{R}$ be the function defined by

$$(x) = (x) \to x\ f(x), \text{ for all } x \in \mathbb{R}.$$

Then which of the following statements is (are) TRUE ?

(A) The function g is always continuous at $x = 0$

(B) If f is continuous at $x = 0$, then g is differentiable at $x = 0$

(C) If g is differentiable at $x = 0$, then f is continuous at $x = 0$

(D) If g is differentiable at $x = 0$, then $\lim_{x \to 0} f(x)$ exists.

8. Consider the matrix

$$M = \begin{bmatrix} 2 & -1 \\ 1 & 0 \end{bmatrix}$$

Let p, q, r, s, a, b, c and d be integers such that

$$M^{26} = \begin{bmatrix} p & q \\ r & S \end{bmatrix} \text{ and } \sum_{k=1}^{26} M^k = \begin{bmatrix} a & b \\ c & d \end{bmatrix}.$$

Then which of the following statements is (are) TRUE ?

(A) There exists a 2×2 invertible matrix N with real entries such that

$$MN = N\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

(B) The value of a is 378

(C) For any two given integers m and n, there exist unique integers x and y such that

$$px + qy = m \text{ and } rx + sy = n$$

(D) For each positive real number t, the system of linear equations

$$(a + t)x + by = 1$$
$$cx + (d + t)y = -1$$

has a unique solution

SECTION-3 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value corresponding to the answer using in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**
  Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;
  Zero Marks : 0 In all other cases.

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9. Let S = {1, 2, 3, …, 10}. Consider the set

X = {R : R is an equivalence relation on the set S such that R has exactly 42 elements}.

Then the number of elements in X is __________.

10. Consider the function $f:\left(-\frac{\pi}{2},\frac{\pi}{2}\right)\to(-\infty,\infty)$ defined by

$$f(x) = (|x| + |x - 1|)\sin x + [x \sin x],$$

where [x sin x] is the greatest integer less than or equal to x sin x.

Let α be the total number of points in the interval $\left(-\frac{\pi}{2},\frac{\pi}{2}\right)$ at which *f* is **NOT** continuous, and let

β be the total number of points in the interval $\left(-\frac{\pi}{2},\frac{\pi}{2}\right)$ at which *f* is **NOT** differentiable.

Then the value of α + β is __________.

11. The number of ways to distribute 10 identical red pens and 14 identical blue pens among four persons such that each person gets 6 pens, is ____________.

12. Let

$$\alpha=\left(1-2\cos\left(\frac{\pi}{11}\right)\right)\left(1-2\cos\left(\frac{3\pi}{11}\right)\right)\left(1-2\cos\left(\frac{9\pi}{11}\right)\right)\left(1-2\cos\left(\frac{27\pi}{11}\right)\right)\left(1-2\cos\left(\frac{81\pi}{11}\right)\right).$$

Then the value of $5 - \alpha^2$ is ____________.

SECTION-4 : (Maximum Marks : 16)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists : **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 **ONLY** if the option corresponding to the correct combination is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –1 In all other cases.

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13. Match each entry in List-I to the correct entry in List-II and choose the correct option.

List-I		List-II	
(P)	If α and β are the distinct roots of the equation $x^2 + x + 1 = 0$, then the quadratic equation with roots $\frac{1}{(\alpha+1)^{2026}}$ and $\frac{1}{(\beta+1)^{2026}}$ is	(1)	$x^2 + x + 1 = 0$
(Q)	If α and β are the distinct roots of the equation $x^2 + x + 1 = 0$, then the quadratic equation with roots $\frac{1}{(\alpha+1)^{2027}}$ and $\frac{1}{(\beta+1)^{2027}}$ is	(2)	$x^2 - x + 1 = 0$
(R)	If γ and δ are the distinct roots of the equation $x^2 - x + 1 = 0$, then the value of $\frac{1}{(\gamma-1)^{2026}} + \frac{1}{(\delta-1)^{2026}}$ is	(3)	$x^2 + x - 1 = 0$
(S)	If p and r are the distinct roots of the equation $x^2 + x - 1 = 0$, then the value of $\frac{1}{(p+1)^3} + \frac{1}{(r+1)^3}$ is	(4)	-1
		(5)	-4

(A) (P)→(1), (Q)→(2), (R)→(5), (S)→(4)

(B) (P)→(3), (Q)→(1), (R)→(4), (S)→(5)

(C) (P)→(1), (Q)→(2), (R)→(4), (S)→(5)

(D) (P)→(2), (Q)→(3), (R)→(5), (S)→(4)

14. Match each entry in List-I to the correct entry in List-II and choose the correct option.

List-I		List-II	
(P)	The number of elements in the set $\{x \in [-\pi, \pi] : \sin^6 x + \cos^4 x = 1\}$	(1)	is 1
(Q)	The number of elements in the set $\left\{x \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right] : \sin^2 x + \cos^6 x = 1\right\}$	(2)	is 2
(R)	The number of elements in the set $\left\{x \in [-\pi, \pi] : \cos^2\left(\frac{x}{2}\right) - \sin^2 x = \frac{1}{2}\right\}$	(3)	is 3
(S)	The number of elements in the set $\left\{x \in [-2\pi, 2\pi] : 6\sin^2\left(\frac{x}{2}\right) - \cos 3x = 3\right\}$	(4)	is 4
		(5)	is 5

(A) (P)→(2), (Q)→(5), (R)→(3), (S)→(4)

(B) (P)→(5), (Q)→(3), (R)→(2), (S)→(4)

(C) (P)→(5), (Q)→(4), (R)→(1), (S)→(3)

(D) (P)→(4), (Q)→(3), (R)→(2), (S)→(5)

15. For real numbers α, β, γ, δ and μ, consider the matrix

$$M = \begin{bmatrix} \alpha & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{3}} & \beta & \frac{1}{\sqrt{3}} \\ \gamma & \delta & \mu \end{bmatrix}$$

Suppose that $MM^T = I$, where M^T is the transpose of the matrix M, and I is the 3 × 3 identity matrix.

Let $\vec{u} = \alpha\hat{i} + \frac{1}{\sqrt{3}}\hat{j} + \gamma k$, $\vec{v} = \frac{1}{\sqrt{2}}\hat{i} + \beta\hat{j} + \delta k$ and $\vec{w} = -\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{3}}\hat{j} + \mu k$.

Match each entry in List-I to the correct entry in List-II and choose the correct option.

	List – I		List – II
(P)	The value of $\gamma^2 + \delta^2$ is	(1)	0
(Q)	If $x\vec{u} + y\vec{v} + z\vec{w} = \hat{j}$ for some real numbers x, y and z, then the value of x is	(2)	1
(R)	The value of $\left\|\vec{u}.(\vec{v} \times \vec{w})\right\|$ is	(3)	$\frac{1}{\sqrt{2}}$
(S)	The value of $\left\|\vec{u} \times (\vec{v} \times \vec{w})\right\|$ is	(4)	$\frac{1}{\sqrt{3}}$
		(5)	$\frac{5}{6}$

(A) (P) → (5), (Q) → (4), (R) → (2), (S) → (1)

(B) (P) → (4), (Q) → (5), (R) → (1), (S) → (2)

(C) (P) → (5), (Q) → (3), (R) → (2), (S) → (1)

(D) (P) → (5), (Q) → (4), (R) → (1), (S) → (2)

16. Match each entry in List-I to the correct entry in List-II and choose the correct option.

	List – I		List – II
(P)	The circle with centre (1,2) and touching the straight line $3x + 4y = 1$, passes through	(1)	the point (1,1)
(Q)	The common tangent to the circle $x^2 + y^2 = 2$ and the parabola $y^2 = 8x$ with positive slope, passes through	(2)	the point (7,9)
(R)	Let M be the end point of the latus rectum of the ellipse $3x^2 + 4y^2 = 48$ such that M lies in the first quadrant. Then the normal to the ellipse drawn at M passes through	(3)	the point (3, 2)
(S)	Let H be the hyperbola whose centre is at the origin, one of the foci is at (5, 0), and one directrix is $5x + 16 = 0$. Then H passes through	(4)	the point (2, 5)
		(5)	the point $(8, 3\sqrt{3})$

(A) (P) → (3), (Q) → (4), (R) → (1), (S) → (2)

(B) (P) → (3), (Q) → (2), (R) → (1), (S) → (5)

(C) (P) → (3), (Q) → (2), (R) → (4), (S) → (5)

(D) (P) → (4), (Q) → (1), (R) → (2), (S) → (3)

(PHYSICS)

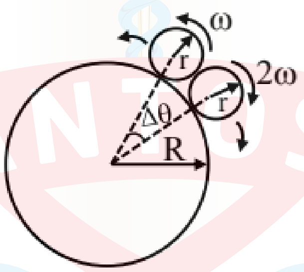
SECTION-1 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks	: +3	If **ONLY** the correct option is chosen;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

1. Consider a large disk of radius R and two smaller disks, each of radius $r = R/50$, lying on its circumference, as shown in the figure. The smaller disks are initially in contact with each other, with an angular separation $\Delta\theta$ between their centers. They are made to roll without slipping in opposite directions, with constant angular velocities ω and 2ω while the large disk is held stationary. The time τ at which the smaller disks are again in contact is :

[Use $\sin(\Delta\theta) = \Delta\theta$ and ignore gravity.]



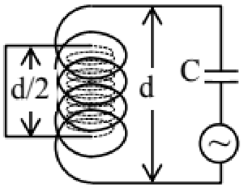
(A) $\tau = 51 \times \left(2\pi - \frac{4}{51}\right) / \omega$

(B) $\tau = 51 \times \left(2\pi - \frac{2}{51}\right) / 3\omega$

(C) $\tau = 51 \times \left(2\pi - \frac{4}{51}\right) / 3\omega$

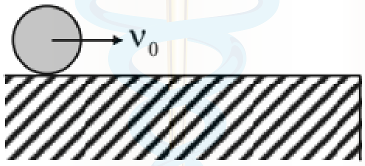
(D) $\tau = 51 \times \left(2\pi - \frac{2}{51}\right) / \omega$

2. Consider a circuit consisting of a capacitor of capacitance C and a coil with N turns per unit length, cross sectional area S and length d, where $d^2 \gg S$. There is another coil of length $d/2$, cross sectional area $S/2$ and $2N$ turns per unit length completely inside the larger coil, as shown in the figure. The ends of this smaller coil are connected with each other by an insulated conducting wire. The self-inductance of the larger coil is L. Neglecting edge effects and all the Ohmic resistances, the resonant frequency of the circuit is:



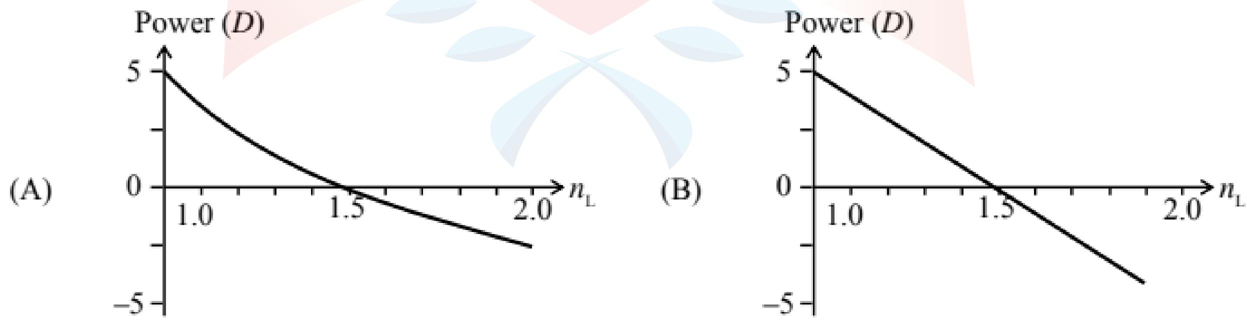
(A) $\frac{4}{\sqrt{15LC}}$ (B) $\frac{6}{\sqrt{5LC}}$ (C) $\frac{2}{\sqrt{3LC}}$ (D) $\sqrt{\frac{2}{3LC}}$

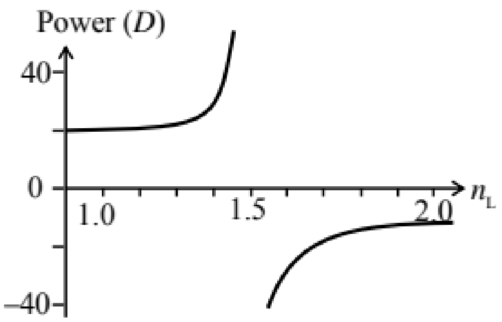
3. A solid cylinder of radius R rolls without slipping with a center of mass speed $v_0 = \sqrt{\frac{gR}{3}}$ on a horizontal surface with a vertical edge, as shown in the figure. Here, g is the acceleration due to the gravity. At the moment when the cylinder loses contact with the surface due to rotation around the corner, the speed of its center of mass is:

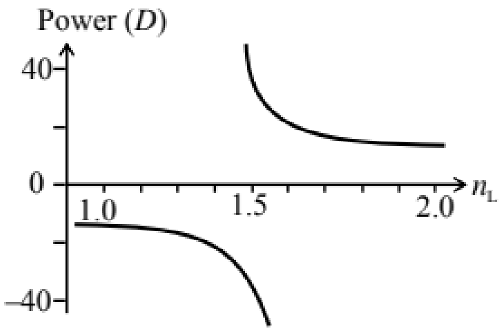


(A) 0 (B) $\sqrt{\frac{5gR}{7}}$ (C) $\sqrt{\frac{gR}{15}}$ (D) $\sqrt{\frac{3gR}{7}}$

4. A double convex lens made of glass of refractive index 1.5 and radii of curvature of the curved surfaces 20 cm each is immersed in a liquid of refractive index n_L. The correct plot showing the variation of the power, in the units of diopter (D), as a function of n_L is :



(C) 

(D) 

SECTION-2 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks	: +4	**ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks	: +3	If all the four options are correct but **ONLY** three options are chosen;
Partial Marks	: +2	If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
Partial Marks	: +1	If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

5. Consider a hydrogen atom with v_k, r_k and K_k denoting the velocity, orbital radius and kinetic energy of the electron in the k^{th} orbit, respectively. The electron undergoes a transition from the n^{th} orbit, emitting radiation corresponding to the Lyman series. Considering h to be the Planck's constant and ϵ_0 the permittivity of the free space, the correct statement(s) is/are:

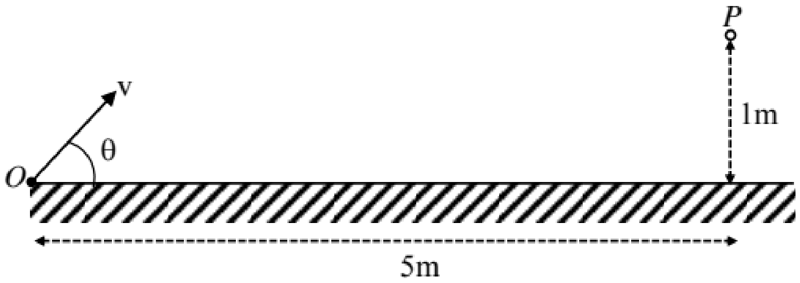
(A) Magnitude of change in kinetic energy of electron can be expressed as $\frac{h}{4\pi}\left|\frac{nv_n}{r_n}-\frac{v_1}{r_1}\right|$.

(B) Magnitude of change in de Broglie wavelength of the electron can be expressed as $\frac{e^2}{4\epsilon_0}\left|\frac{1}{K_n}-\frac{1}{K_1}\right|$.

(C) Frequency of the radiation emitted can be expressed as $\frac{e^2}{8\pi\epsilon_0 h}\left(\frac{1}{r_1}-\frac{1}{r_n}\right)$.

(D) Magnitude of change in total energy of the electron can be expressed as $\frac{h}{2\pi}\left|\frac{v_1}{r_1}-\frac{nv_n}{r_n}\right|$.

6. A particle is thrown with a speed v from a point O at an angle θ with the horizontal plane such that it passes through the point P at a height of 1 m and horizontal distance of 5 m from O, as shown in the figure. If acceleration due to gravity is g ms^{-2}, then the correct statement (s) is/are :



(A) If $\theta = 45°$, then $v = \frac{5\sqrt{g}}{2}$ ms^{-1}

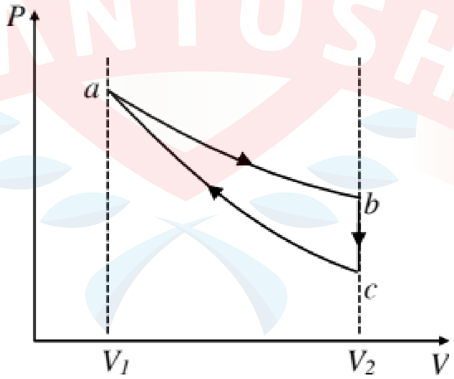
(B) If $\theta = 45°$, the particle reaches its maximum height before it reaches P.

(C) If $\theta = 30°$, the particle reaches its maximum height after reaching P.

(D) If $\theta = \tan^{-1}\left(\frac{1}{5}\right)$, then v = $125\sqrt{g}$ ms^{-1}

7. A quasi-static cycle of a monoatomic ideal gas contains an isothermal process (***ab***), followed by an isochoric process (***bc***) and an adiabatic process (***ca***) as shown in the figure. The volumes of the gas are V_1 and V_2 at ***a*** and ***b***, respectively. If the cycle has heat input Q_{in} and output Q_{out}, then the efficiency of the cycle is defined as $\eta = \frac{Q_{in} - Q_{out}}{Q_{in}}$. The correct statement(s) is/are:

[Given : ln 2 $\approx$ 0.7]



(A) If V_2/V_1=8, the heat released in the process ***bc*** is smaller than the heat absorbed in the process ***ab***.

(B) For a given value of V_2/V_1, η does not depend on the temperature of the isothermal process

(C) If V_2/V_1 = 8, then the temperature of the gas at ***a*** is 4 times the temperature of the gas at ***c***.

(D) If V_2/V_1 = 8, then the pressure of the gas at ***a*** is 4 times the pressure of the gas at ***b***.

8. The electric field associated with an electromagnetic wave travelling in vacuum is given by $E_0 \sin(3y + 4z + \omega t)\hat{i}$, where ω is the angular frequency. All quantities are in SI units. The correct statement(s) about this wave is/are:

[Given: speed of light in vacuum $c = 3 \times 10^8$ ms^{-1}.]

(A) The wave is travelling in $-\frac{1}{5}(3\hat{j} + 4\hat{k})$ direction.

(B) The magnitude of the wave vector is 0.5 m^{-1}.

(C) The value of ω is 1.5×10^9 rad s^{-1}.

(D) The magnetic field associated with this wave is given by $\frac{E_0}{c}\sin(3y + 4z + \omega t)\,(4\hat{j} - 3\hat{k})$

SECTION-3 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value corresponding to the answer using in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;
Zero Marks : 0 In all other cases.

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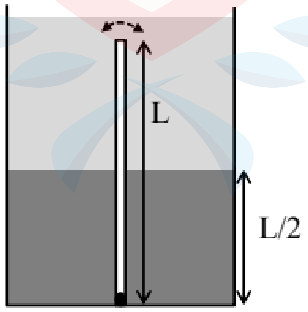
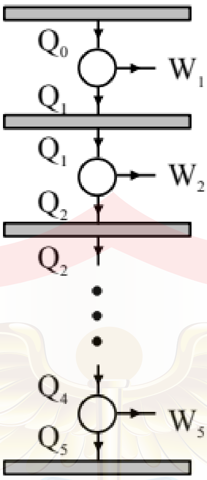
9. A tank contains two immiscible liquids of densities 6ρ and 2ρ. The higher density liquid is filled up to a height $L/2$ from the bottom. A thin rod of density ρ and length L is fully immersed and hinged at the bottom so that it can oscillate freely, as shown in the figure. If the rod is slightly disturbed from its equilibrium, the time period of small oscillations is $\frac{2\pi}{n}\sqrt{\frac{L}{g}}$, where g is the acceleration due to gravity.

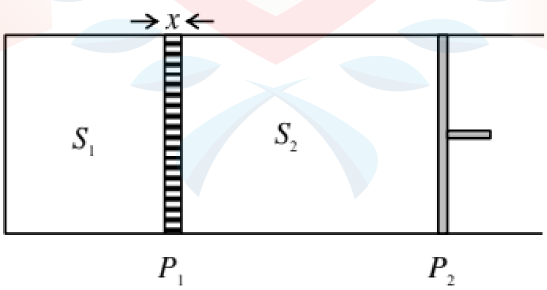
The value of n is:



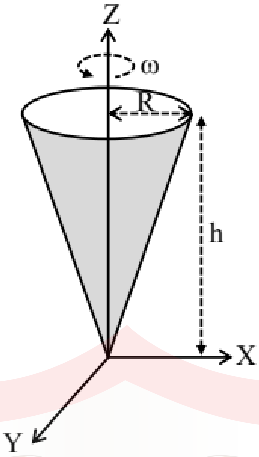
10. As shown in the figure, five Carnot engines, each with efficiency η and same number of cycles per unit time, are operating between six heat reservoirs. The amount of heat released per cycle by one engine is completely absorbed by the next engine. Consider Q_0 to be the amount of heat absorbed per cycle by the first engine and W as the amount of total work done by all the engines per cycle, then the net efficiency of the system is found to be $\eta_{net} = \frac{W}{Q_0} = \frac{211}{243}$. The value of η is:



11. As shown in the figure, an insulated container is fitted with a thermally conducting but immovable partition (P_1) and a freely movable but thermally insulated piston (P_2). The partition P_1 with thermal conductivity K, cross sectional area A and width x divides the container into two sections, S_1 and S_2, each containing one mole of a monoatomic gas. The piston P_2 moves freely such that the gas in S_2 is always at the atmospheric pressure. Initially, the difference between the temperatures of S_1 and S_2 is ΔT_0. The time it takes for the temperature difference to become $\frac{\Delta T_0}{2}$ is nxR/KA, where R is the universal gas constant. The value of n is: [Given: $\ln 2 \approx 0.7$]



12. A hollow, right circular cone of base radius R and height h, with its tip at the origin is rotating about the Z-axis with an angular velocity ω, as shown in the figure. The cone carries a total charge Q uniformly distributed on its curved surface. The magnitude of magnetic field at a point (0, 0, z), where z >> R and z >> h, is $\frac{n\mu_0}{4\pi}\frac{QR^2\omega}{z^3}$. The value of n is:



SECTION-4 : (Maximum Marks : 16)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists : **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated **according to the following marking scheme:**
  Full Marks : +4 **ONLY** if the option corresponding to the correct combination is chosen;
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
  Negative Marks : –1 In all other cases.

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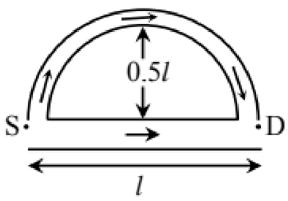
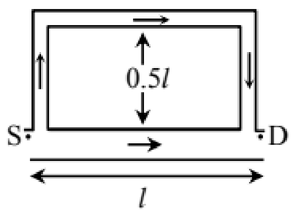
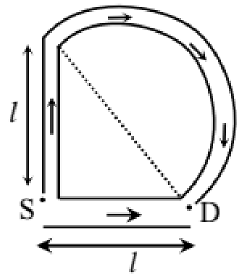
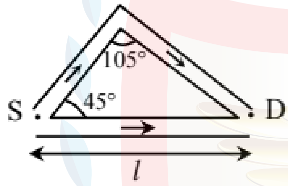
13. **List-I** shows four configurations made of straight and semi-circular narrow tubes containing air. A sound wave of wavelength $\lambda = 0.29$ m enters these structures at the point S and a sound detector is placed at D. Between the points S and D, the sound travels only through the tubes. **List-II** contains the possible smallest values of l (refer to the figures) for which the detector D records maximum amplitude. Ignore effects of sharp corners. [Given cos(15°) = 0.97]

Choose the option that best describes the match between the entries in **List-I** to those in **List-II**.

List-I		**List-II**	
(P)		(1)	1.32 m

(Q)  (2) 1.19 m

(R)  (3) 0.51 m

(S)  (4) 0.29 m

(5) 0.13 m

(A) P→4, Q→3, R→5, S→1 (B) P→4, Q→3, R→1, S→5

(C) P→3, Q→4, R→1, S→2 (D) P→3, Q→4, R→5, S→2

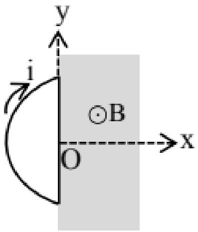
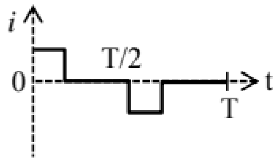
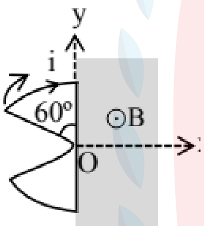
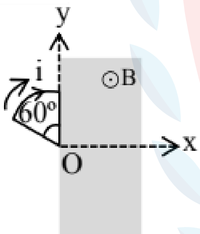
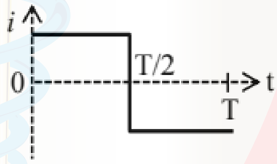
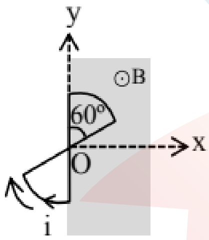
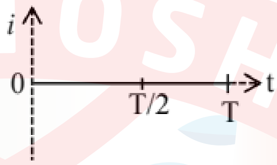
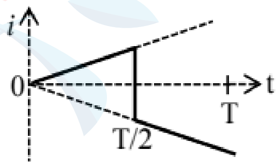
14. In the **List-I**, four optical effects are mentioned. The physical phenomena of light which are essential to describe these optical effects are given in **List-II**. Choose the option which describes the correct match between the entries in **List-I** to those in **List-II**.

List-I		**List-II**	
(P)	Colorful sky in north polar region (Aurora Borealis)	(1)	Dispersion and reflection
(Q)	Partially polarized sun light	(2)	Total internal reflection
(R)	Rainbow	(3)	Diffraction
(S)	Dark and bright fringes	(4)	Scattering of light by molecules in the atmosphere
		(5)	Emission of radiation from oxygen and nitrogen atoms excited by charged particles

(A) P→5, Q→4, R→1, S→3 (B) P→4, Q→2, R→1, S→3

(C) P→4, Q→1, R→2, S→3 (D) P→5, Q→4, R→1, S→2

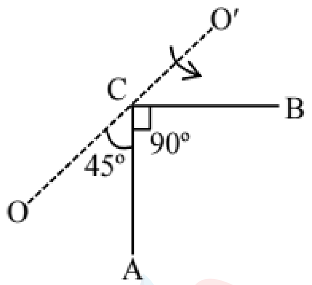
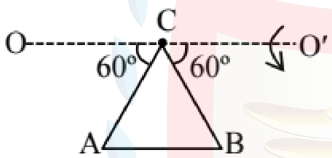
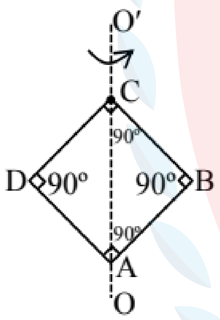
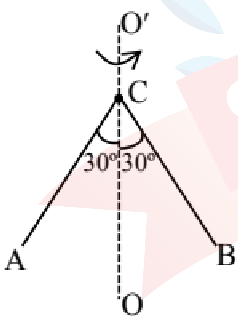
15. **List-I** contains four conducting loops lying in the XY plane, as shown in the figures. The loops are rotating about Z axis passing through the point 0 with time period T in clockwise direction. The region x > 0 contains a uniform magnetic field B in the +z direction. **List-II** contains the qualitative variation of the induced current *i*(t) for each of these loops. Choose the option which describes the correct match between the entries in **List-I** to those in **List-II**.

List-I	List-II
(P) 	(1) 
(Q) 	(2) 
(R) 	(3) 
(S) 	(4) 
	(5) 

(A) P → 5, Q → 4, R → 1, S → 3
(B) P → 3, Q → 2, R → 5, S → 4
(C) P → 3, Q → 2, R → 1, S → 4
(D) P → 5, Q → 1, R → 2, S → 3

16. **List-I** shows four planar structures made of uniform solid rods each of mass m and length l. In the **List-II** the possible moment of inertia of these structures about an axis OCO′, which lies in the plane of the structures, are given.

Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

List-I	List-II
(P) 	(1) $\frac{5}{4}m\ell^2$
(Q) 	(2) $\frac{1}{6}m\ell^2$
(R) 	(3) $\frac{1}{12}m\ell^2$
(S) 	(4) $\frac{2}{3}m\ell^2$
	(5) $\frac{1}{3}m\ell^2$

(A) $P \to 5, Q \to 1, R \to 4, S \to 2$
(B) $P \to 1, Q \to 3, R \to 4, S \to 2$
(C) $P \to 5, Q \to 3, R \to 2, S \to 1$
(D) $P \to 5, Q \to 4, R \to 2, S \to 1$

JEE ADVANCED-2026
(PAPER-1)
ANSWER KEY

CHEMISTRY

1.	(B)	**2.**	(C)	**3.**	(A)	**4.**	(C)	**5.**	(ABCD)	**6.**	(AC)
7.	(BC)	**8.**	(ABC)	**9.**	(9.80)	**10.**	(8)	**11.**	(4)	**12.**	(6)
13.	(C)	**14.**	(A)	**15.**	(C)	**16.**	(B)				

MATHEMATICS

1.	(D)	**2.**	(C)	**3.**	(B)	**4.**	(C)	**5.**	(AC)	**6.**	(AD)
7.	(BD)	**8.**	(ACD)	**9.**	(2520)	**10.**	(5)	**11.**	(206)	**12.**	(4)
13.	(C)	**14.**	(B)	**15.**	(A)	**16.**	(B)				

PHYSICS

1.	(C)	**2.**	(C)	**3.**	(B)	**4.**	(A or B)	**5.**	(AC)	**6.**	(AB)
7.	(ABC)	**8.**	(AC)	**9.**	(1.73)	**10.**	(0.33)	**11.**	(0.66)	**12.**	(0.5)
13.	(D)	**14.**	(A)	**15.**	(C)	**16.**	(A)				

HINTS AND SOLUTION
(CHEMISTRY)

1. **(B)**

Sol. $n = 0.5$

$$(2\text{ bar, }600\text{ K})\xrightarrow[\substack{P_{ext} = P\text{ bar}\\(2<P<8)}]{①}(P\text{ bar, }600\text{ K})\xrightarrow[P_{ext} = 8\text{ bar}]{②}(8\text{ bar, }600\text{ K})$$

$W = W_1 + W_2$

$= -0.5\,R\,600\left[1-\frac{P}{2}\right] - 0.5\,R\,600\left[1-\frac{8}{P}\right]$

$W = -300\,R\left[2-\frac{P}{2}-\frac{8}{P}\right]$

$\Rightarrow \frac{dW}{dP} = -300R\left[-\frac{1}{2}+\frac{8}{P^2}\right] = 0$

$\Rightarrow \frac{1}{2} = \frac{8}{P^2} \quad \Rightarrow \quad P = 4\text{ bar}$

$W = -300R\left[2-\frac{4}{2}-\frac{8}{4}\right]$

$= -300R\,[2-2-2]$

$= 600R = W_{min}$

Ans = B

2. **(C)**

Sol. $R \underset{K_b}{\overset{K_f}{\rightleftharpoons}} P$

$t = 0 \quad R_0 \qquad 0$

$K_c = \frac{K_f}{K_b} = \frac{1}{4} = \frac{[P]_{eq}}{[R]_{eq}}$

$\Rightarrow [R]_{eq} = 4(P)_{eq}$

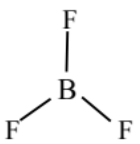
Given condition satisfied in option (C)

$\Rightarrow \frac{[P]_{eq}}{R_0} = 0.2$

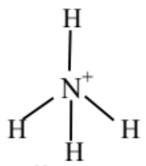
$\Rightarrow \frac{[R]_{eq}}{R_0} = 0.8$

Ans (C)

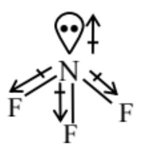
3. **(A)**



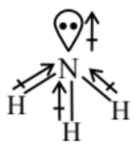
$\mu_{net} = 0$



$\mu_{net} = 0$



$\mu_{net} = 0.8\times 10^{-30}$ Cm

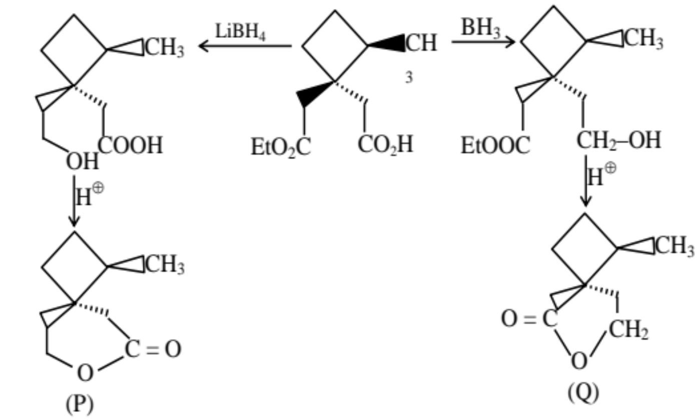


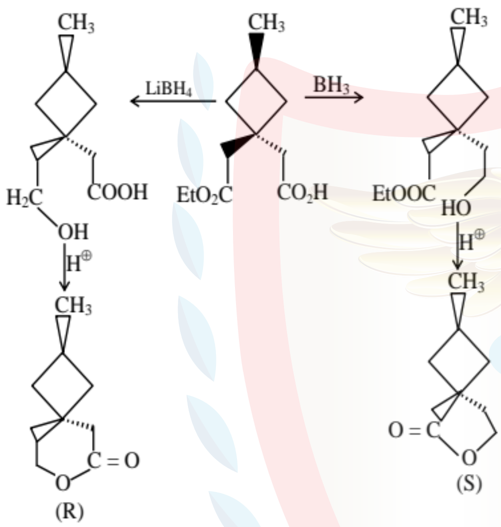
$\mu_{net} = 4.90\times 10^{-30}$ Cm

μ_{net} order $BF_3 = NH_4^+ < NF_3 < NH_3$

4. **(C)**

Sol.





5. **(A,B,C,D)**

Sol. (i) The energy of subshells in multi electron system is compared on the basis of (n + *l*) rule.

(n + *l*) value for E_{2s} (Li) = 2

(n + *l*) value for E_{2p} (Li) = 3

E_{2s} (Li) < E_{2p} (Li)

(ii) In single electron system energy of subshell depends on the value of n

E_{2s} (H) = E_{2p} (H) as n is same.

(iii) For Li, Z = 3 more effective nuclear charge pulling its 2s electron more closer and resulting more negative lower energy.

6. **(A,C)**

Sol. $MnO_2 + \text{conc. } HCl \rightarrow MnCl_2 + \underset{\text{(greenish yellow gas)}}{\underset{(X)}{Cl_2}} + H_2O$

$NH_3 + \underset{(\text{excess})}{Cl_2} \rightarrow \underset{(Y)}{NCl_3} + HCl$

$Cl_2 + \underset{(\text{excess})}{F_2} \xrightarrow{573K} \underset{(Z)}{ClF_3}$

(A) Cl_2 is used for sterilizing drinking water

(B) NCl_3 is non-planar as hybridization of nitrogen is sp^3 (pyramidal)

(C) ClF_3 is used in enrichment of ^{235}U to produce volatile UF_6

$(U + 3ClF_3 \rightarrow UF_6 + 3ClF)$

(D) NCl_3 is weaker Lewis base than NH_3 because the highly electronegative chlorine atoms pull electron density away from the nitrogen (–I effect)

7. **(B,C)**

Sol. $PtF_6 + O_2 \rightarrow O_2[PtF_6]$

$X^+ = O_2^+$

$Y^\ominus = [PtF_6]^{-1}$

(A) Bond order of O_2^+ is 2.5

(B) Electronic configuration of Pt is $[Xe]4f^{14}\,5d^9\,6s^1$

$[PtF_6]^{-1} \Rightarrow Pt^{+5}$:- $4f^{14}\,5d^5$

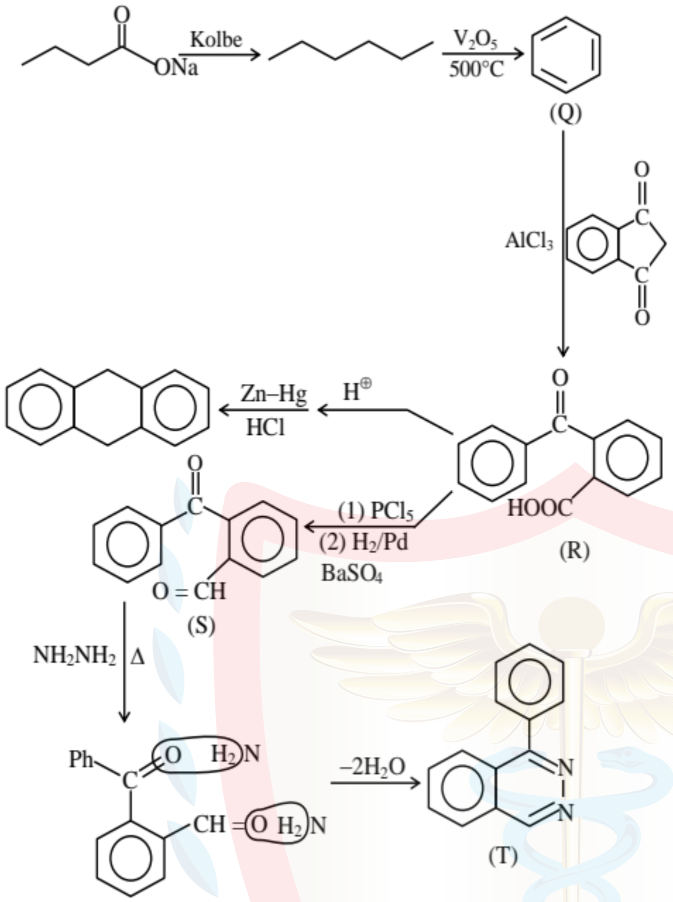
5 electron is valence d orbital

(C) PtF_6 oxidizes O_2 into O_2^+ hence act as oxidant

(D) In this reaction fluorination does not take place

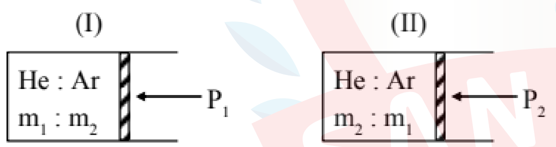
8. **(A,B,C)**

Sol.



9. **(9.80)**

Sol.



Given $M_{Ar} = 10\,M_{He}$ $\qquad M_{He} = M$

$P_1 = 5\,P_2$

$V_1 = V_2 = V$

$T_1 = T_2 = T$

Applying ideal gas equation :

vessel (I) $\Rightarrow$ $P_1V = \left[\frac{m_1}{M} + \frac{m_2}{10M}\right]RT$

vessel (II) $\Rightarrow$ $P_2V = \left[\frac{m_2}{M} + \frac{m_1}{10M}\right]RT$

Dividing (II) / (I) $\Rightarrow$ $\frac{P_2}{P_1} = \frac{\frac{m_2}{M} + \frac{m_1}{10M}}{\frac{m_1}{M} + \frac{m_2}{10M}} = \frac{1}{5}$

$\Rightarrow 5m_2 + \frac{m_1}{2} = m_1 + \frac{m_2}{10}$

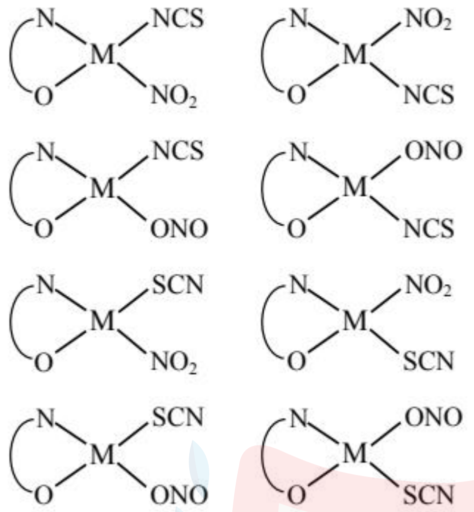
$\Rightarrow 5m_2 - \frac{m_2}{10} = m_1 - \frac{m_1}{2}$

$\Rightarrow \frac{49m_2}{10} = \frac{m_1}{2} \Rightarrow \frac{m_1}{m_2} = 9.8$

Ans 9.80

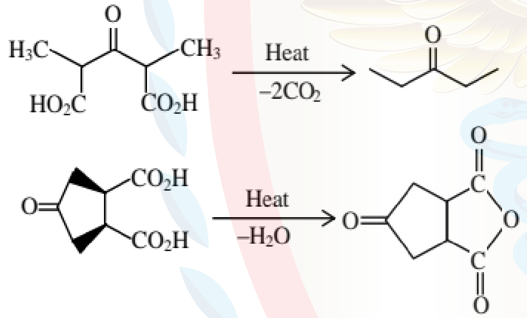
10. **(8.0)**

Sol. Total geometrical isomers are 8 which are given below



11. **(4)**

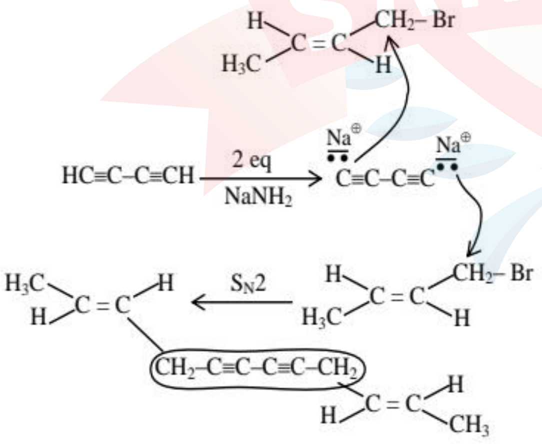
Sol.



Ans.(4)

12. **(6)**

Sol.



6 Collinear (straight)

13. **(C)**

Sol. (P) Physisorption $\Rightarrow x(g) \rightarrow x(s)$

$\Rightarrow \Delta S < 0, \Delta H < 0$

(Q) Diamond $\rightarrow$ Graphite

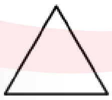
$\Rightarrow \Delta S > 0, \Delta H < 0$

Graphite has weaker vander waal forces of attraction between layers & hence, greater disorder & graphite is more stable in normal condition

(R) Denaturation of protein

$\Delta H > 0$ [Heat absorption]

$\Delta S > 0$ [relative bonds between polymer protein chain break]

(S) $CH_3CH = CH_2(g) \rightarrow$  (g)

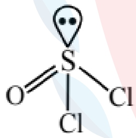
$\Delta H > 0$ [Cyclopropane is unstable due to angular strain]

$\Delta S < 0$ [$\because$ open chain has more freedom of rotation]

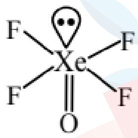
$\Rightarrow$ P – 2 ; Q – 5 ; R – 1 ; S – 4

14. **(A)**

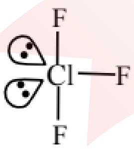
Sol.

$SOCl_2 \Rightarrow$ 

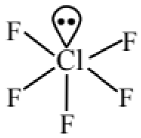
(Pyramidal)

$XeOF_4 \Rightarrow$ 

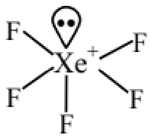
(Square Pyramidal)

$ClF_3 \Rightarrow$ 

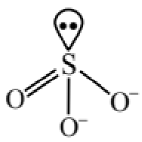
(T-shape)

$ClF_5 \Rightarrow$ 

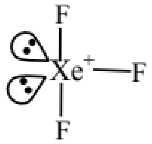
(Square Pyramidal)

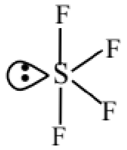
$XeF_5^{\oplus} \Rightarrow$ 

(Square Pyramidal)

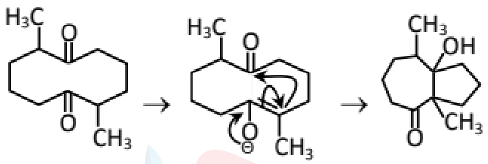
$SO_3^{2-} \Rightarrow$ 

(Pyramidal)

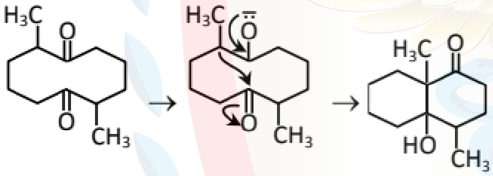
$XeF_3^{\oplus} \Rightarrow$  (T-shape)

$SF_4 \Rightarrow$  (See-saw)

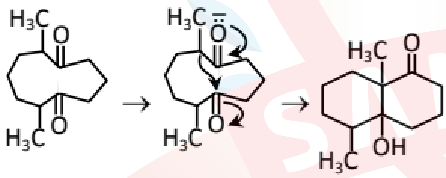
15. **(C)**

Sol. (P) 

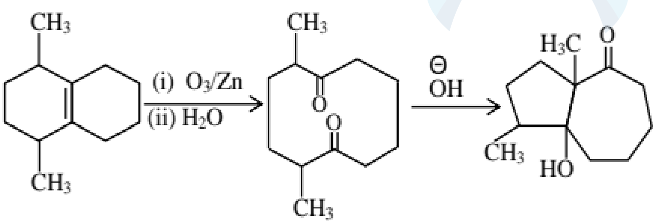
P → 2

(Q) 

Q → 1

(R) 

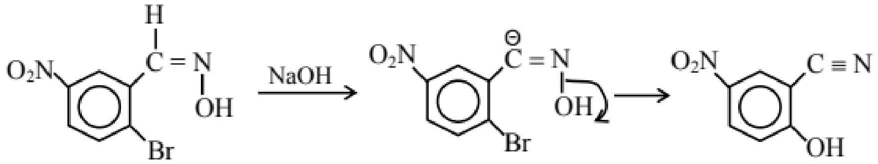
R → 5

(S) 

S → 3

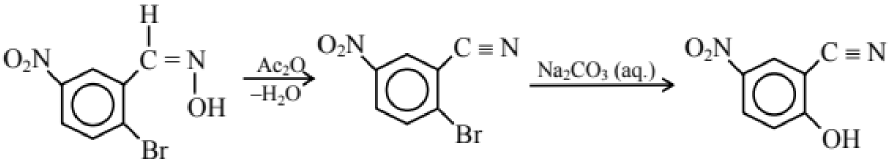
16. **(B)**

Sol. (P)



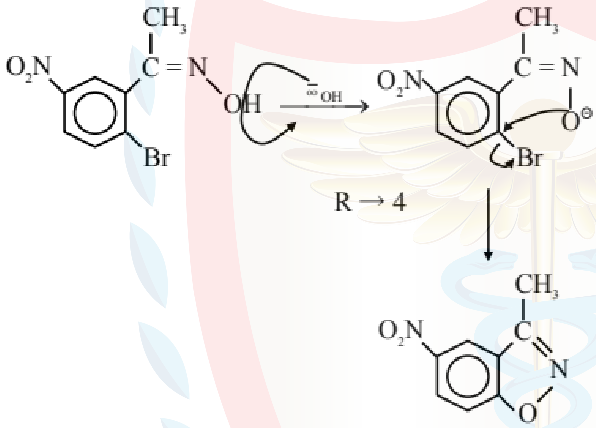
P → 1

(Q)



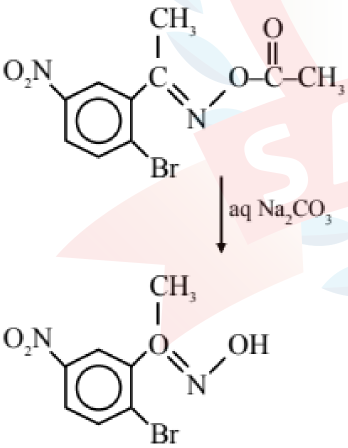
Q → 2

(R)



R → 4

(S)



S → 5

(MATHEMATICS)

1. **(D)**

Sol. $f(x) = \sqrt{x}\ell nx - x + 1$

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

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

$f''(x) = \frac{2\sqrt{x}\left(\frac{1}{x}\right) - (\ell nx + 2).\frac{1}{\sqrt{x}}}{4x}$

$= \frac{2 - \ell nx - 2}{4x\sqrt{x}} = \frac{-\ell nx}{4.x^{3/2}}$

If f' is decreasing

$f''(x) \le 0$

$\frac{-\ell nx}{4x^{3/2}} \le 0 \Rightarrow \ell nx \ge 0 \Rightarrow x \ge 1 \Rightarrow x \in (1, \infty)$

So, options A is wrong.

Now, $f'(x) = \frac{\ell nx + 2 - 2\sqrt{x}}{2\sqrt{x}}$

$\because f'(1) = 0$ ($\therefore$ x = 1 is critical point)

$x \in (0,1)$

$\sqrt{x} < 1$ and $\ell nx < 0$

$g(x) = \ell nx + 2 - 2\sqrt{x}$; $g(1) = 0$

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

$x \in (0,1)$

$g'(x) > 0$

g(x) is inc.

$x < 1$

$g(x) < g(1)$

$\ell nx + 2 - 2\sqrt{x} < 0$

$x \in (1, \infty)$

$g'(x) < 0$

g(x) is dec.

$x > 1$

$g(x) < g(1)$

$\ell nx + 2 - 2\sqrt{x} < 0$

$\Rightarrow$ for $x \in (0, \infty)$

$\ell nx + 2 - 2\sqrt{x} < 0$

$$\therefore f'(x) = \frac{\ell nx + 2 - 2\sqrt{x}}{2\sqrt{x}} < 0 \quad \forall x \in (0, \infty)$$

$\therefore$ f(x) is decreasing $\forall x \in (0, \infty)$

It has no local maxima and no local minima

option (D) is correct.

2. **(C)**

Sol. $y = x^2$

$\frac{dy}{dx} = 2x = 4 \Rightarrow x = 2$ (slope at point P is 4)

$\Rightarrow P(2, 4)$

$x^2 + y^2 = 2 \Rightarrow 2x + 2y\frac{dy}{dx} = 0 \Rightarrow \frac{dy}{dx} = -\frac{x}{y}$

Slope at point Q is – 1

$\therefore -\frac{x}{y} = -1 \Rightarrow x = y$

Since Q lies in first quadrant

$x^2 + x^2 = 2 \Rightarrow x = 1$ and $y = x = 1$

$\Rightarrow Q\,(1, 1)$

$x^2 + 4y^2 = 8$

$$2x + 8y\frac{dy}{dx} = 0 \Rightarrow \frac{dy}{dx} = -\frac{x}{4y}$$

$\because$ Slope of tangent at point R is $-\frac{1}{2}$

$$\Rightarrow -\frac{x}{4y} = -\frac{1}{2} \Rightarrow x = 2y$$

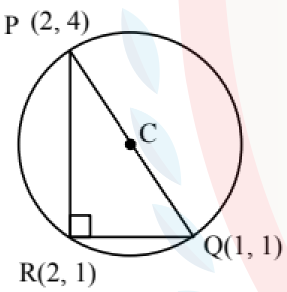
Since R is lies in first quadrant

$(2y)^2 + 4y^2 = 8 \Rightarrow 8y^2 = 8 \Rightarrow y = 1$

$x = 2y = 2$

$\Rightarrow R(2, 1)$

Find the equation of circle passing through P, Q and R



Since PQR is a Right angle triangle so radius of circle is $\frac{\sqrt{10}}{2} = \sqrt{\frac{5}{2}}$

3. **(B)**

Sol. A matrix can be obtained from 3×3 identity matrix by elementary row transformation iff it is non-singular matrix.

$$\begin{vmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{vmatrix} = 0$$

$$\begin{vmatrix} 1 & 1 & 1 \\ 2 & 3 & 4 \\ 1 & 2 & 1 \end{vmatrix} = -2 \neq 0$$

$$\begin{vmatrix} 1 & 1 & 1 \\ 2 & 3 & 4 \\ 2 & 5 & 8 \end{vmatrix} = 0$$

$$\begin{vmatrix} 1 & 1 & 1 \\ -1 & 1 & 2 \\ 0 & 2 & 3 \end{vmatrix} = 0$$

Option (B) is correct

4. **(C)**

Sol. $\cot^{-1}(\cot(-11)) + 10\sin\left(2\cos^{-1}\left(\frac{1}{\sqrt{2}}\right)\right) + 10\sin\left(2\tan^{-1}2\right)$

$= 4\pi - 11 + 10\sin(\pi/2) + 10\sin\left(2\tan^{-1}2\right)$

$(\because 4\pi - 11 \in (0, \pi))$

$= 4\pi - 11 + 10 + 10\sin\left(2\tan^{-1}2\right)$

Let $\tan^{-1}2 = \theta \quad \left(\theta \in \left(0, \frac{\pi}{2}\right)\right)$

$\Rightarrow \tan\theta = 2$

So $\sin 2\theta = \frac{2\tan\theta}{1+\tan^2\theta} = \frac{4}{5}$

$\Rightarrow$ Ans. $= 4\pi - 11 + 10 + 10 \times \frac{4}{5} = 4\pi + 7$

5. **(A,C)**

Sol. Box I Box II

6R 8R

9G 12G

Total Red balls = 14

Total Green balls = 21

Total balls = 35

$$P(E_1) = \frac{15}{35} = \frac{3}{7}$$

$$P(E_2) = \frac{20}{35} = \frac{4}{7}$$

$$P(F_1) = \frac{14}{35} = \frac{2}{5}$$

$$P(F_2) = \frac{21}{35} = \frac{3}{5}$$

Now, $P\left(\frac{F_1}{E_1}\right) = \frac{6}{15} = \frac{2}{5}$

$$P\left(\frac{F_1}{E_2}\right) = \frac{8}{20} = \frac{2}{5}$$

Option (C) is correct

$$P\left(\frac{F_2}{E_2}\right) = \frac{12}{20} = \frac{3}{5}$$

$$\because P\left(\frac{F_1}{E_1}\right) > P\left(\frac{F_2}{E_2}\right)$$

Option D is incorrect

Since $P\left(\frac{F_1}{E_1}\right) = \frac{2}{5}$ and $P(F_1) = \frac{2}{5}$

$$P\left(\frac{F_1}{E_1}\right) = P(F_1)$$

So E_1 and F_1 are not independent.

Option (A) is correct

And $P\left(\frac{F_2}{E_2}\right) = \frac{3}{5}$ and $P(F_2) = \frac{3}{5}$

$$P\left(\frac{F_2}{E_2}\right) = P(F_2)$$

So E_2 and F_2 are not dependent events.

Option (B) is incorrect

6. **(A,D)**

Sol. Since plane P contains the line

$$L: \frac{x-1}{2} = \frac{y-3}{3} = \frac{z+2}{1}$$ and perpendicular to the plane x + 2y + 3z = 4

So normal vector of plane

$$\vec{n} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 1 \\ 1 & 2 & 3 \end{vmatrix}$$

$$\vec{n} = 7\hat{i} - 5\hat{j} + \hat{k}$$

Since line passes through (1, 3, –2)

So plane P is also passes through if

$7(x - 1) - 5(y - 3) + 1(z + 2) = 0$

Plane P: $7x - 5y + z = -10$

Option A is correct

Since plane P_1 is parallel to plane P

So $7x - 5y + z = d$

We are given that P_1 passes through the point (4, 2, 2)

So $7(4) - 5(2) + 2 = d \Rightarrow d = 20$

$\Rightarrow$ Plane P_1: $7x - 5y + z = 20$

Distance between plane P and P_1 = $\left|\frac{d_1 - d_2}{\sqrt{A^2 + B^2 + C^2}}\right| = \left|\frac{-10-20}{\sqrt{49+25+1}}\right| = \frac{30}{\sqrt{75}}$

Option B is incorrect

Distance from (0, 0, 0) to plane P = $\frac{10}{\sqrt{75}} = \frac{2}{\sqrt{3}} = \frac{2\sqrt{3}}{3}$

Option C is incorrect

Acute angle between plane

P & $2x + 2y + z = 3$

$$\cos\theta = \frac{\vec{n}_1 . \vec{n}_2}{|\vec{n}_1||\vec{n}_2|} = \frac{7\times2+(-5)\times2+1\times1}{\sqrt{75}\times3} = \frac{1}{3\sqrt{3}}$$

$$\theta = \cos^{-1}\left(\frac{1}{3\sqrt{3}}\right)$$

Option D is correct.

7. **(B, D)**

Sol. (A) Suppose $f(x)=\begin{cases}\frac{1}{x}\sin\left(\frac{1}{x}\right) & , \quad x\neq 0\\ 0 & , \quad x=0\end{cases}$

$$g(x)=xf(x)=\begin{cases}\sin\left(\frac{1}{x}\right) & , \quad x\neq 0\\ 0 & , \quad x=0\end{cases}$$

which is not continuous at x = 0

(B) $f(0^-)=f(0^+)=f(0)$

$$g'(0)=\lim_{h\to 0}\frac{g(h)-g(0)}{h}, \quad \because\ g(0)=0$$

$$g'(0)=\lim_{h\to 0}\frac{g(h)}{h}=\lim_{h\to 0}\frac{hf(h)}{h}$$

$g'(0)=\lim_{h\to 0}f(h)=f(0)$, which is finite since f(x) is continuous at x = 0.

$\therefore$ g(x) is differentiable at x = 0

(C) $g'(0)=\lim_{h\to 0}f(h)$,

$\because$ g(x) is given as differentiable at x = 0,

we have $\lim_{h\to 0}f(h)$ existing

but nothing can be said about f(0).

Hence, we cannot comment on continuity of f(x) at x = 0 just because g(x) is differentiable at x = 0.

(D) It correct as proven in option (C)

8. **(A,C,D)**

Sol. $M^2=\begin{bmatrix}2 & -1\\ 1 & 0\end{bmatrix}\begin{bmatrix}2 & -1\\ 1 & 0\end{bmatrix}=\begin{bmatrix}3 & -2\\ 2 & -1\end{bmatrix}$

$M^3=\begin{bmatrix}3 & -2\\ 2 & -1\end{bmatrix}\begin{bmatrix}2 & -1\\ 1 & 0\end{bmatrix}=\begin{bmatrix}4 & -3\\ 3 & -2\end{bmatrix}$

By observation:

$M^k=\begin{bmatrix}k+1 & -k\\ k & 1-k\end{bmatrix}$

$2+3+4+.....+27=\frac{26}{2}(29)$

$\therefore\ M^{26}=\begin{bmatrix}27 & -26\\ 26 & -25\end{bmatrix}=\begin{bmatrix}p & q\\ r & s\end{bmatrix}$

$\Rightarrow p=27\ ;\ q=-26\ ;\ r=26\ ;\ s=-25$

$\sum_{k=1}^{26}M^k=\begin{bmatrix}\Sigma k+1 & -\Sigma k\\ \Sigma k & \Sigma 1-k\end{bmatrix}=\begin{bmatrix}377 & -351\\ 351 & -325\end{bmatrix}$

$\Rightarrow a=377\ ;\ b=-351\ ;\ c=351\ ;\ d=-325$

Option A:

$$MN = N\begin{bmatrix}1 & 1\\0 & 1\end{bmatrix}$$

Let $N = \begin{bmatrix}\alpha & \beta\\ \gamma & \delta\end{bmatrix}$

$\Rightarrow \begin{bmatrix}2 & -1\\1 & 0\end{bmatrix}\begin{bmatrix}\alpha & \beta\\ \gamma & \delta\end{bmatrix} = \begin{bmatrix}\alpha & \beta\\ \gamma & \delta\end{bmatrix}\begin{bmatrix}1 & 1\\0 & 1\end{bmatrix}$

$\Rightarrow \begin{bmatrix}2\alpha-\gamma & 2\beta-\delta\\ \alpha & \beta\end{bmatrix} = \begin{bmatrix}\alpha & \alpha+\beta\\ \gamma & \gamma+\delta\end{bmatrix}$

$\Rightarrow 2\alpha - \gamma = \alpha \ ; \ 2\beta - \delta = \alpha + \beta$

$\alpha = \gamma \ ; \ \beta = \gamma + \delta$

$\Rightarrow \alpha = \gamma ; \ \beta = \alpha + \delta$

$\therefore$ N can be $\begin{bmatrix}\alpha & \alpha+\delta\\ \alpha & \delta\end{bmatrix}$

where $\alpha, \delta \in R$

$\therefore$ A is correct

Option B is wrong

Option C :

system : $27x - 26y = m$

$26x - 25y = n$

$\Delta = \begin{vmatrix}27 & -26\\26 & -25\end{vmatrix} = -675 + 676 = 1$

$\because$ $D \neq 0 \Rightarrow$ consistent system with unique solution

$\therefore$ C is correct

Option D :

system :

$a = 377 ; b = -351 ; c = 351 ; d = -325$

$(377 + t)x - 351y = 1$

$351x + (t - 325)y = -1$

$\Delta = \begin{vmatrix}377+t & -351\\351 & t-325\end{vmatrix}$

$\Rightarrow \Delta = (377 + t)(t - 325) + (351)^2$

$= t^2 + 52t + (351)^2 - (377)(325)$

$= t^2 + 52t + (351)^2 - (351+ 26)(351 - 26)$

$= t^2 + 52t + (351)^2 - ((351)^2 - (26)^2)$

$= t^2 + 52t + (26)^2$

$= (t + 26)^2$

$\because$ t is +ve $\Rightarrow \Delta > 0 \ \forall$ real positive t

$\therefore$ system is consistent

$\Rightarrow$ (D) is correct

9. **(2520.00)**

Sol. The total number of such relations is 2520.

Here is how you can think about it step-by-step :

An equivalence relation is just a way of breaking a group into smaller, separate teams (called equivalence classes). Within any team, every member connects to everyone else, including themselves.

This means a team with 'n' people creates n^2 total connections.

For our problem, we have 10 people in total. We need to split them into teams so that the sum of the squared team sizes equals exactly 42.

We need to find combinations of numbers that add up to 10, but whose squares add up to 42. If you test out different numbers, only two combinations actually work :

Option A : One team of b, one team of 2 and two teams of 1. Check total people : $(6 + 2 + 1 + 1 = 10)$ check total connections : $(6^2 + 2^2 + 1^2 + 1^2 = 36 + 4 + 1 + 1 = 42)$.

Option B : One team of 5, one team of 4 and one team of 1. Check total people : $(5 + 4 + 1 = 10)$ Check total connections : $(5^2 + 4^2 + 1^2 = 25 + 16 + 1 = 42)$.

Now we just count how many ways we can sort our 10 people into these two setups.

Fo option A(6, 2, 1, 1) : First, pick 6 people out of 10 for the big team.

Then, pick 2 out of the remaining 4 for the second team. The last 2 people automatically form their own single-peson teams.

Because the two single person teams are identical in size, we divide by 2 to avoid double-counting them.

$$\text{Ways} = \frac{10!}{6!\,2!\,1!\,1!} \times \frac{1}{2!} = 1260$$

For option B

Pick 5 people out of 10 fo the first team, then 4 out of the remaining 5 for the second team.

The last person is left by themselves.

$$\text{Ways} = \frac{10!}{5!\,4!\,1!} = 1260$$

Total count

Add the tow possibilities together : $(1260 + 1260 = 2520)$

10. **(5.00)**

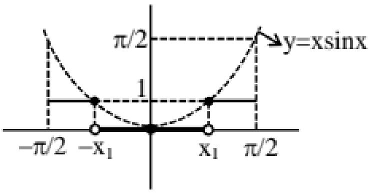
Sol. Observe $[x \sin x]$

let $g(x) = x\sin x$

$g'(x) = \sin x + x\cos x \geq 0$

$g'(x) \geq 0 \ \forall \ x \in \left[0, \frac{\pi}{2}\right)$

$g'(x) \le 0 \ \forall \ x \in \left(-\frac{\pi}{2}, 0\right]$



$[x\sin x]$ discontinuous at $x = x_1, -x_1$; $x_1 \in \left(0, \frac{\pi}{2}\right)$

$[x\sin x]$ not diff. at $x = x_1, -x_1, x_1 \in \left(0, \frac{\pi}{2}\right)$

Now $y = (|x| + |x - 1|) \sin x$

(i) continuous $\forall \ x \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

(ii) Not differentiable at $x = 1$, differentiable at $x = 0$

Here $x_1 \neq 1$

Now

(i) for diffrentiability

$$f(x) = \underbrace{(|x| + |x-1|)\sin x}_{f_1(x)} + \underbrace{[x \sin x]}_{f_2(x)}$$

at $x = x_1, -x_1$

$f_1(x)$ is differentiable & $f_2(x)$ is not differentiable

Hence $f(x)$ is not differentiable

at $x = 1$; $f_1(x)$ is not differentiable & $f_2(x)$ is differentiable

$\Rightarrow f(x)$ is not differentiable

at $x = 0$

$f_1(x)$ & $f_2(x)$ both differentiable

Hence $\beta = 3$

(ii) for continuity, we can clearly say

at $x = x_1, -x_1$,

$f(x)$ will be discontinuous

$\alpha = 2$

$\boxed{\alpha + \beta = 5}$

11. **(206.00)**

Sol. Let r_i & b_i are number of pens recieved by i^{th} person

$\therefore r_i + b_i = 6$

& $r_1 + r_2 + r_3 + r_4 = 10$

also $b_i = 6 - r_i$

$\because r_i \geq 0$ and $b_i \geq 0$

$\Rightarrow r_i \leq 6$

$\therefore 0 \leq r_i \leq 6$

$\therefore$ we have to find possible cases of

$r_1 + r_2 + r_3 = r_4 = 10, \; 0 \leq r_i \leq 6$

$\therefore$ Required cases $= {}^{10+4-1}C_3 - [{}^4C_1 \times {}^6C_3]$

$= {}^{13}C_3 - 4 \times {}^6C_3$

$= 286 - 80$

$= 206$

12. **(4.00)**

Sol. Let $\theta = \frac{\pi}{11}$ then

$a = (1 - 2\cos\theta)(1 - 2\cos3\theta)(1 - 2\cos9\theta) \dots (1 - 2\cos81\theta)$

$\because 1 - 2\cos\theta$

$$= 1 - 2\left(2\cos^2\frac{\theta}{2} - 1\right)$$

$$= 3 - 4\cos^2\frac{\theta}{2}$$

$$= \frac{\left(3 - 4\cos^2\frac{\theta}{2}\right)\cos\frac{\theta}{2}}{\cos\frac{\theta}{2}}$$

$$= -\frac{\left(4\cos^3\frac{\theta}{2} - 3\cos\frac{\theta}{2}\right)}{\cos\frac{\theta}{2}}$$

$$= -\frac{\cos\frac{3\theta}{2}}{\cos\frac{\theta}{2}}$$

$$\therefore\ \alpha = \left(-\frac{\cos\frac{3\theta}{2}}{\cos\frac{\theta}{2}}\right)\times\left(-\frac{\cos\left(\frac{9\theta}{2}\right)}{\cos\frac{3\theta}{2}}\right)\times\dots\left(-\frac{\cos\frac{243\theta}{2}}{\cos\frac{81\theta}{2}}\right)$$

$$\alpha = -\frac{\cos\frac{243\theta}{2}}{\cos\frac{\theta}{2}}$$

Now $\frac{243\theta}{2} = \frac{243\pi}{22} = 11\pi + \frac{\pi}{22}$

$$\Rightarrow \alpha = \frac{-\cos\left(11\pi + \frac{\pi}{22}\right)}{\cos\left(\frac{\pi}{22}\right)} = 1$$

$\boxed{\because 5 - \alpha^2 = 4}$ Ans.

13. **(C)**

Sol. (P) α, β are roots of $x^2 + x + 1 = 0$

$\therefore \alpha = w, \beta = w^2$

$(\omega + 1)^{2026} = (-\omega^2)^{2026} = (\omega^2)^{2025} . \omega^2$

$= w^2$

$(\omega^2 + 1)^{2026} = (-\omega)^{2026} = \omega$

Equation whose roots are $\frac{1}{(\alpha+1)^{2026}}$ and $\frac{1}{(\beta+1)^{2026}}$

$x^2 + x + 1 = 0 \therefore P \to 1$

(Q) $(\omega + 1)^{2027} = (-\omega^2)^{2027} = -(\omega^2)^{2025} . (\omega^2)^2$

$= -\omega$

$(\omega^2 + 1)^{2027} = (-\omega^2)^{2027} = -w^2$

$x^2 + (\omega + \omega^2) x + w^3 = 0$

$x^2 - x + 1 = 0$

(R) Roots of $x^2 - x + 1 = 0$

$x = -\omega, x = -\omega^2$

$(\gamma - 1)^{2026} + (\delta - 1)^{2026}$

$(\omega + 1)^{2026} + (\omega^2 + 1)^{2026}$

$\Rightarrow \omega^2 + \omega = -1$

(S) $p + r = -1$ $pr = -1$

$p^2 + r^2 + 2pr = 1$

$p^2 + r^2 - 2 = 1 \therefore p^2 + r^2 = 3$

$p^3 + r^3 + 3pr (p + r) = -1$

$p^3 + r^3 - 3(-1) = -1 \therefore p^3 + r^3 = -4$

$(p + 1) (r + 1) = pr + p + r + 1$

$= -1 - 1 + 1$

$= -1$

$$\frac{1}{(p+1)^3} + \frac{1}{(r+1)^3} = \frac{(p+1)^3 + (r+1)^3}{[(p+1)(r+1)]^3}$$

$$= \frac{p^3 + r^3 + 2 + 3p^2 + 3p + 3r^2 + 3r}{(-1)^3}$$

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

14. **(B)**

Sol. (P) $\sin^6 x + \cos^4 x = 1$

$\sin^2 x \le 1$; $\cos^2 x \le 1$

$\sin^6 x \le \sin^2 x$ $\cos^4 x \le \cos^2 x$

$\sin^6 x + \cos^4 x = 1$ only if

$\sin^6 x = \sin^2 x$ and $\cos^4 x = \cos^2 x$

$\sin^2 x = 0$ and $\cos^2 x = 0$

or $\sin^4 x = 1$ $\cos^2 x = 1$

$x = -\pi, 0, \pi, -\frac{\pi}{2}, \frac{\pi}{2}$

(Q) $\sin^2 x + \cos^6 x = 1$

$\sin^2 x = 1$ $\cos^2 x = 0$

or $\sin^2 x = 0$ $\cos^2 x = 1$

$x = \frac{\pi}{2}, 0, \frac{\pi}{2}$

(R) $\cos^2 \frac{x}{2} - \sin^2 x = \frac{1}{2}$

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

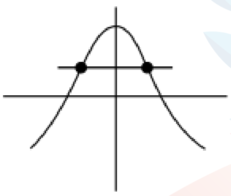
$\Rightarrow 1+\cos x - 2 + 2\cos^2 x = 1$

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

$\cos x = \frac{-1 \pm \sqrt{1+16}}{4}$

$\cos x = \frac{-1+\sqrt{17}}{4}, \frac{-1-\sqrt{17}}{4}$

only possibility $\cos x = \frac{-1+\sqrt{17}}{4}, \frac{-1-\sqrt{17}}{4}$



Number of elements in $[-\pi, \pi]$ is 2

(S) $6\sin^2 \frac{x}{2} - \cos 3x = 3$

$-\cos 3x = 3\left(1 - 2\sin^2 \frac{x}{2}\right)$

$-\left[4\cos^3 x - 3\cos x\right] = 3\left[\cos x\right]$

$4\cos^3 x = 0$

$x = \frac{-3\pi}{2}, -\frac{\pi}{2}, \frac{\pi}{2}, \frac{3\pi}{2}$

in $[-2\pi, 2\pi]$ 4 solutions

15. **(A)**

Sol. $M=\begin{bmatrix}\alpha & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{3}} & \beta & \frac{1}{\sqrt{3}}\\ \gamma & \delta & \mu\end{bmatrix}$

$\vec{u}=\alpha\hat{i}+\frac{1}{\sqrt{3}}\hat{j}+\gamma\hat{k}$

$\vec{v}=\frac{1}{\sqrt{2}}\hat{i}+\beta\hat{j}+\delta\hat{k}$

$w=-\frac{1}{\sqrt{2}}\hat{i}+\frac{1}{\sqrt{3}}\hat{j}+\mu\hat{k}$

$\alpha^2+\frac{1}{3}+\gamma^2=1 \quad \therefore\ \alpha^2+\gamma^2=\frac{2}{3} \quad \ldots(1)$

$\frac{1}{2}+\beta^2+\delta^2=1 \quad \beta^2+\delta^2=\frac{1}{2} \quad \ldots(2)$

$\frac{1}{2}+\frac{1}{3}+\mu^2=1 \quad \mu^2=\frac{1}{6} \quad \ldots(3)$

$\gamma^2+\delta^2+\mu^2=1$

For Q

$x\vec{u}+y\vec{v}+z\vec{w}=\hat{j}$

Dot with $x\ \vec{u}.\vec{u}+y\,\vec{u}.\vec{v}+z\vec{u}-\vec{w}=\vec{u}.\hat{j}$

$x=\frac{1}{\sqrt{3}}$

For R

$\vec{u},\vec{v},\vec{w}$ are mutually

perpendicular unit vectors

$\left|\vec{u}.\left(\vec{v}\times\vec{w}\right)\right|$

$\left[\vec{u}\ \ \vec{v}\ \ \vec{w}\right]=1$

For S

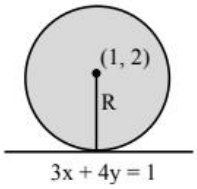
$\vec{u}\times\left(\vec{v}\times\vec{w}\right)$

$\left(\vec{u}.\vec{w}\right)\vec{v}-\left(\vec{u}.\vec{v}\right)\vec{w}$

$=0-0\ =0$

16. (B)

Sol. (P)



R = ⊥ distance from (1,2) to line

$\therefore\ R = \frac{3+8-1}{5} = 2$

$\therefore$ Circle $(x-1)^2 + (y-2)^2 = 4$

point (3,2) satisfy

(Q) $y^2 = 4x,\ x^2 + y^2 = 2$

Let equation of tangent for $y^2 = 4x$

$\therefore\ y = mx + \frac{2}{m}$

It is also a tangent for $x^2 + y^2 = 2$

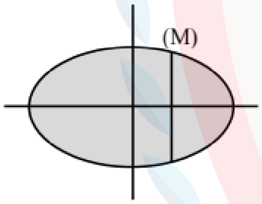
So $\left|\frac{2/m}{\sqrt{1+m^2}}\right| = \sqrt{2}$ (condition of tangency)

if $m = +1$

$\therefore$ equation of tangent = y + x + 2

so (7,9) satisfy

(R)



$\frac{x^2}{16} + \frac{y^2}{12} = 1 \qquad \therefore\ e = \frac{1}{2}$

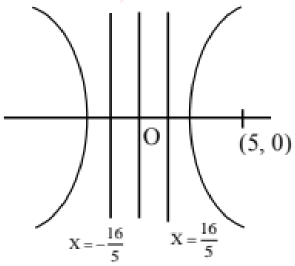
$M\left(ae, \frac{b^2}{a}\right) = \left(4 \times \frac{1}{2}, \frac{12}{4}\right) = (2,3)$

Equation of normal at (2,3) is

$\frac{a^2x}{x_1} - \frac{b^2y}{y_1} = a^2e^2 \Rightarrow 2x - y = 1$

which passes through (1,1)

(S)



$ae = 5$ and $ae = \frac{16}{5}$

$\therefore\ a = 4,\ e = \frac{5}{4}$

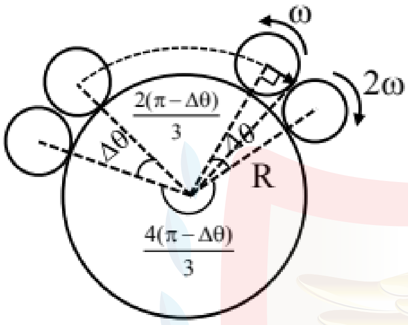
$\therefore\ \frac{x^2}{16} - \frac{y^2}{9} = 1$ is a hyperbola

which passes through $\left(8, 3\sqrt{3}\right)$

(PHYSICS)

1. **(C)**

Sol.



$$\frac{2}{3}(\pi - \Delta\theta)\left(R + \frac{R}{50}\right) = \omega t.\frac{R}{50}$$

$$\frac{\Delta\theta}{2} = \frac{R/50}{R + \frac{R}{50}} = \frac{1}{51}$$

$$\Delta\theta = \frac{2}{51}\text{rad}$$

$$t = \frac{102}{3\omega}(\pi - \Delta\theta)$$

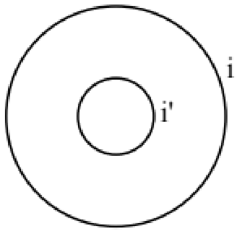
$$t = \frac{102}{3\omega}\left[\pi - \frac{2}{51}\right]$$

$$t = \frac{51}{3\omega}\left(2\pi - \frac{4}{51}\right)\text{sec}$$

2. **(C)**

Sol. Larger coil, $L = \mu_0 \pi R^2 N^2 \ell = \mu_0 S N^2 d$

Smaller coil, $L' = \mu_0 \frac{S}{2}(2N)^2 \frac{d}{2} = L$



For mutual inductance $(\mu_0 N i) \times \frac{S}{2}(2N)\frac{d}{2} = Mi$

$$M = \frac{\mu_0 S N^2 d}{2} = \frac{L}{2}$$

Induced emf in bigger coil $e = -L\frac{di}{dt}$

In smaller coil $e' = -M\frac{di}{dt} - \frac{L}{2}\frac{di}{dt} = -L\frac{di'}{dt}$

$$\frac{di'}{dt} = \frac{1}{2}\frac{di}{dt}$$

$$i' = \frac{i}{2}$$

Net emf in bigger coil

$$e = e_1 - e_2 = -L\frac{di}{dt} + M\frac{di'}{dt} = -L\frac{di}{dt} - \frac{L}{2}.\frac{1}{2}\frac{di}{dt}$$

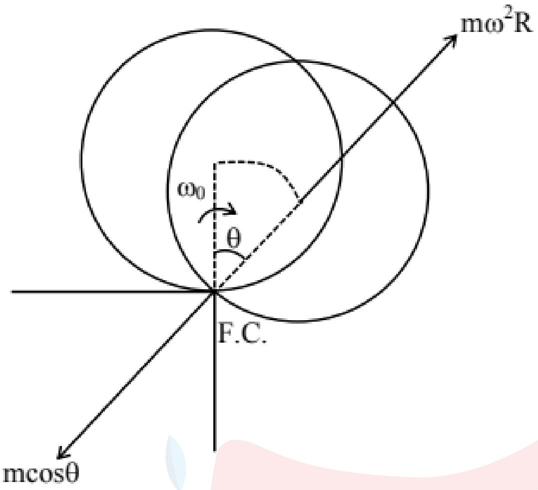
$$= -\frac{3}{4}L\frac{di}{dt}$$

$\therefore$ $L_{eq} = \frac{3L}{4}$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{3L}{4}.C}} = \frac{2}{\sqrt{3LC}}$$

3. **(B)**

Sol.



$\omega_0 = \sqrt{g/3R}$

to loose contact

$m\omega^2 R = mg\cos\theta$

$\omega^2 R = g\cos\theta$

W.E.T

$mgR\,(1-\cos\theta) = \frac{1}{2}\cdot\frac{3}{2}mR^2\,(\omega^2-\omega_0^2)$

$g - g\cos\theta = \frac{3}{4}R(\omega^2 - \frac{g}{3R})$

$g - \omega^2 R = \frac{3}{4}R\omega^2 - \frac{g}{4}$

$\frac{5g}{4} = \frac{7}{4}R\omega^2$

$\omega = \sqrt{\frac{5}{7}g/R}$

$v = R\omega = \sqrt{5g\frac{R}{7}}$

4. **(A) or (B)**

Sol. $\frac{1}{f}=\left(\frac{1.5}{n}-1\right)\left(\frac{1}{0.2}-\frac{1}{-0.2}\right)=\left(\frac{1.5}{n}-1\right)\cdot 10$

According to NCERT, $P=\frac{1}{f}$

If $P=\frac{1}{f}$ (By NCERT)

$P=\frac{15}{n}-10$

Then, correct **(Ans. A)**

OR

If $P=\frac{n}{f}$

Then $P=(1.5-n)\cdot 10$

Then, correct **(Ans. B)**

5. **(A, C)**

Sol. $\frac{mv_k^2}{r_k}=\frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r_k^2}$

or, $mv_k^2 r_k=\frac{e^2}{4\pi\varepsilon_0}$ .....(1)

$mv_k r_k=\frac{kh}{2\pi}$ .....(2)

$(1)/(2)\Rightarrow v_k=\frac{e^2}{2kh\varepsilon_0}$

$r_k=\frac{\varepsilon_0 k^2h^2}{\pi e^2 m}$

$k_k=\frac{1}{2}mv_k^2=\frac{1}{2}m\frac{e^4}{4k^2h^2\varepsilon_0^2}=\frac{me^4}{8k^2h^2\varepsilon_0^2}=\frac{e^2}{8\pi\varepsilon_0 r_k}$

K = n to 1 for Lymen series

$\frac{h}{4\pi}\left|\frac{nv_n}{r_n}-\frac{v_1}{r_1}\right|=\left|\frac{nh}{2\pi}\cdot\frac{v_n}{2r_n}-\frac{h}{2\pi}\frac{v_1}{2r_1}\right|$

$=\left|mv_nr_n\frac{v_n}{2r_n}-mv_1r_1\frac{v_1}{2r_1}\right|$

$=\left|\frac{1}{2}mv_n^2-\frac{1}{2}mv_1^2\right|=\Delta KE\Rightarrow$ (A) is correct

$\frac{e^2}{4\varepsilon_0}\left|\frac{1}{k_n}-\frac{1}{k_1}\right|=\frac{e^2}{4\varepsilon_0}\left|\frac{2}{mv_n^2}-\frac{2}{mv_1^2}\right|$

$=\frac{me^2}{2\varepsilon_0}\left|\frac{1}{\lambda_n^2}-\frac{1}{\lambda_1^2}\right|\neq|\lambda_n-\lambda_1|$ (Here λ_n indicates de-Broglie wave – length)

$\Rightarrow$ (B) is wrong

Frequency f of radiation emitted is given by

$h_f = K_1 - K_n$

$$f = \frac{K_1}{h} - \frac{K_n}{h} = \frac{e^2}{8\pi\varepsilon_0 h r_1} - \frac{e^2}{8\pi\varepsilon_0 h r_n}$$

$$= \frac{e^2}{8\pi\varepsilon_0 h}\left(\frac{1}{r_1} - \frac{1}{r_n}\right) \Rightarrow \text{(C) correct}$$

Change in total energy $= K_1 - K_n = \frac{e^2}{8\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

also, $\frac{h}{2\pi}\left|\frac{v_1}{r_1} - \frac{nv_n}{r_4}\right| = \frac{h}{2\pi}\left|v_1\frac{mv_1}{h}2\pi - nv_n\frac{mv_n}{nh}2\pi\right|$

$= |mv_1^2 - mv_2^2| = \frac{K_1 - K_n}{2} \Rightarrow$ (D) is wrong.

6. **(A, B)**

Sol. $y = x\tan\theta - \frac{1}{2}\frac{gx^2}{v^2\cos^2\theta}$

Passes through (5, 1)

$\Rightarrow \quad 1 = 5 \times 1 - \frac{25g}{2v^2\cos^2\theta}$

(A) If $\theta = 45°$, then

$$1 = 5 \times 1 - \frac{25g}{2v^2\left(\frac{1}{\sqrt{2}}\right)^2} \Rightarrow \frac{25g}{v^2} = 4$$

$$v^2 = \frac{25g}{4}$$

$$v = \frac{5\sqrt{g}}{2} \text{ m/s} \Rightarrow \text{(A) is correct.}$$

(B) If $\theta = 45°$

$$R = \frac{v^2\sin 90°}{g} = \frac{25g}{4g} = 6.25 \text{ m}$$

$$\frac{R}{2} = 3.125 \text{ m} < 5\text{m}$$

Hence, particle reaches maximum height before reaching P

$\Rightarrow$ (B) is correct

(C) If $\theta = 30°$,

$$y = x\tan\theta\left(1 - \frac{x}{R}\right)$$

$$1 = \frac{5}{\sqrt{3}}\left(1 - \frac{5}{R}\right) \Rightarrow \frac{5}{R} = 1 - \frac{\sqrt{3}}{5}$$

$$\Rightarrow R = \frac{25}{5-\sqrt{3}} \Rightarrow \frac{R}{2} = \frac{12.5}{5-\sqrt{3}} = 3.83 < 5$$

$\Rightarrow$ Particle reaches maximum height before reaching P.

$\Rightarrow$ (C) is wrong.

(D) If $\theta = \tan^{-1}\left(\frac{1}{5}\right) \Rightarrow \tan\theta = \frac{1}{5}$, $\cos\theta = \frac{5}{\sqrt{26}}$

$$\therefore\ 1 = 5\times\frac{1}{5} - \frac{g\times 5^2}{2v^2\times\left(\frac{5}{\sqrt{26}}\right)^2} \Rightarrow v\to\infty \Rightarrow \text{(D) incorrect.}$$

7. **(A, B, C)**

Sol. $C_v = \frac{3R}{2}$, $C_p = \frac{5R}{2}$, $\gamma = \frac{5}{3}$

$$Q_{in} = Q_{ab} = nRT_a\,\ell n\left(\frac{V_2}{V_1}\right)$$

$$Q_{out} = -Q_{bc} = -nC_v(T_c - T_b) = nC_v(T_a - T_c)$$

also, $TV^{\gamma-1}$ = constant for ca

$$\Rightarrow T_aV_1^{2/3} = T_cV_2^{2/3}$$

(A) $Q_{ab} + Q_{bc} + Q_{ca} > 0$ (Clockwise P-V cycle)

$Q_{ab} + Q_{bc} + 0 > 0$

$Q_{ab} > -Q_{bc} \quad\Rightarrow\quad$ (A) is correct

(B) $$\eta = \frac{Q_{in} - Q_{out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$$

$$= 1 - \frac{nC_v(T_a - T_c)}{nRT_a\ell n\left(\frac{V_2}{V_1}\right)}$$

$$= 1 - \frac{C_v}{R}\cdot\left(\frac{(1 - T_c/T_a)}{\ell n(V_2/V_1)}\right)$$

$$= 1 - \frac{C_v}{R}\left(\frac{1-(V_1/V_2)^{2/3}}{\ell n\left(\frac{V_2}{V_1}\right)}\right)$$

$\Rightarrow$ Independent of $T_a \Rightarrow$ (B) is correct

(C) $\frac{V_2}{V_1} = 8 \Rightarrow \frac{T_a}{T_c} = 8^{2/3} = 4$

$\Rightarrow$ (C) is correct

(D) $P_aV_a = P_bV_b$

$\Rightarrow \quad \frac{P_a}{P_b} = \frac{V_b}{V_a} = \frac{V_2}{V_1} = 8 \neq 4$

$\Rightarrow$ (D) is wrong

8. **(A, C)**

Sol. $\vec{E} = E_0 \sin\left(\omega t + (x\hat{i} + y\hat{j} + z\hat{k}).5\left(\frac{3\hat{j}}{5} + \frac{4\hat{k}}{5}\right)\right)\hat{i}$

$\Rightarrow$ Wave propagating along $\hat{v} = -\left(\frac{3\hat{j}}{5} + \frac{4\hat{k}}{5}\right)$

$\Rightarrow$ (A) is correct

(B) Wave vector is $-5\left(\frac{3\hat{j}}{5} + \frac{4\hat{k}}{5}\right) \Rightarrow$ its magnitude is $5m^{-1}$

$\Rightarrow$ (B) is wrong

(C) $C = \frac{\omega}{k} \Rightarrow \omega = ck = 15 \times 10^8$ rad/s

$\Rightarrow$ (C) is correct

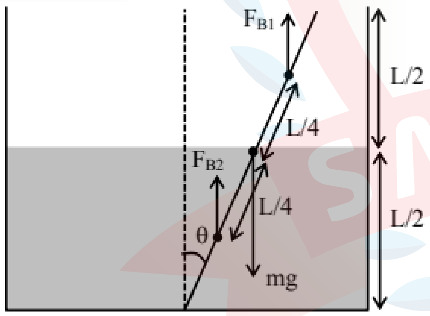
(D) $\hat{B} = \hat{v} \times \hat{E} = -\left(\frac{3\hat{j}}{5} + \frac{4\hat{k}}{5}\right) \times \hat{i} = -\frac{1}{5}\left(-3\hat{k} + 4\hat{j}\right) = \frac{3\hat{k}}{5} - \frac{4\hat{j}}{5}$

$\therefore \quad \vec{B} = \frac{E_0}{5C} \sin(3y + 4z + \omega t)\left(3\hat{k} - 4\hat{j}\right)$

$\Rightarrow$ (D) is wrong

9. **(1.73)**

Sol.



$\tau_{\text{about hinge}} = F_{B1}\frac{3L}{4}\sin\theta + F_{B2}\frac{L}{4}\sin\theta - mg\frac{L}{2}\sin\theta$

$F_{B1} \approx 2\rho\frac{L}{2}Ag$

$F_{B2} \approx 6\rho\frac{L}{2}Ag$ [if θ is small]

$m = \rho LA$

$$\therefore \tau = \left[\rho \ell A g \frac{3L}{4} + 3\rho L A g \frac{L}{4} - \rho L A g \frac{L}{2}\right]\theta$$

$$= \rho A g L^2 \left[\frac{3}{4} + \frac{3}{4} - \frac{1}{2}\right]\theta = \rho A g L^2 \theta$$

$$I = \frac{mL^2}{3} = \frac{\rho L A L^2}{3}$$

Since τ is restoring

$$\therefore \alpha = -\frac{3\rho A g L^2}{\rho A L^3}\theta = \frac{-3g}{L}\theta$$

$$\therefore T = 2\pi\sqrt{\frac{L}{3g}}$$

$\therefore$ n = $\sqrt{3}$ = 1.732 Ans.

10. **(0.33)**

Sol. From the given information

$W_n = \eta\, Q_{n-1}$

$Q_n = Q_{n-1} - W_n = Q_{n-1}(1-\eta)$

$\therefore Q_1 = Q_0(1-\eta)$

$Q_2 = Q_1(1-\eta) = Q_0(1-\eta)^2$

.

.

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$Q_5 = Q_0(1-\eta)^5$

$\therefore$ Total work $= Q_0 - Q_5 = Q_0[1-(1-\eta)^5]$

$$\therefore \eta_{net} = \frac{Q_0 - Q_5}{Q_0} = 1-(1-\eta)^5 = \frac{211}{243}$$

$$\therefore (1-\eta)^5 = 1 - \frac{211}{243} = \frac{32}{243}$$

$$\therefore 1-\eta = \frac{2}{3} \Rightarrow \eta = \frac{1}{3} = 0.33$$

11. **(0.66)**

Sol. Let at any instant temperature difference be $(T_{S1} - T_{S2})$

$$\therefore \frac{dQ}{dt} = \frac{KA(T_{s1} - T_{s2})}{x}$$

Since V_{S1} = constant $\Rightarrow dQ = nC_V dT_1 = \frac{3}{2}RdT_1$

Since P_{S2} = constant $\Rightarrow dQ = nC_P dT_2 = \frac{5}{2}RdT_2$

$$\therefore \frac{d(\Delta T)}{dt} = \frac{dT_1}{dt} - \frac{dT_2}{dt} = -\frac{dQ/dt}{\frac{3}{2}R} - \frac{dQ/dt}{\frac{5}{2}R}$$

$$\therefore -\frac{kA\Delta T}{xR}\left(\frac{2}{3}+\frac{2}{5}\right) = \frac{d(\Delta T)}{dt}$$

$$\Rightarrow \frac{d(\Delta T)}{dt} = -\frac{kA\Delta T}{xR}\times\frac{16}{15}$$

$$\Rightarrow -\int_{\Delta T_0}^{\Delta T_0/2}\frac{d(\Delta T)}{\Delta T} = \int_0^t \frac{16}{15}\frac{KA}{xR}dt$$

$$\Rightarrow \ell n2 = \frac{16}{15}\frac{KA}{xR}t$$

$$\therefore t = \frac{0.7\times 15xR}{16KA}$$

$$\therefore n = 0.65625 \approx 0.66$$

12. (0.5)

Sol. The system can be treated as a magnetic dipole.

$$\therefore \frac{M}{L} = \frac{q}{2m}$$

$$\therefore M = \frac{q}{2m}L = \frac{Q}{2m}\cdot\frac{1}{2}mR^2\omega = \frac{Q\omega R^2}{4}$$

$$\therefore B = 2\frac{\mu_0}{4\pi}\frac{M}{r^3} = \frac{\mu_0}{2\pi}\cdot\frac{Q\omega R^2}{4\cdot z^3} = \frac{\mu_0}{8\pi}\frac{QR^2\omega}{z^3}$$

$$\therefore n = 0.5$$

13. (D)

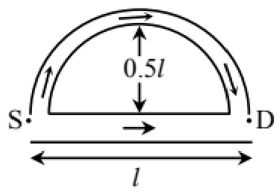
Sol. (P) Path difference :

$\Delta x = \pi R - 2R$

$= (\pi - 2)\frac{\ell}{2}$

For maxima $(\pi-2)\frac{\ell}{2} = n\lambda$

$\ell_{min} = \frac{2\lambda}{\pi - 2} = 0.51m$



(Q) Path difference

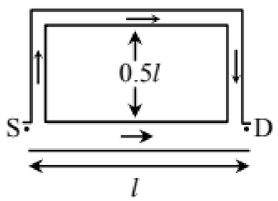
$\Delta X = 2\ell - \ell = \ell$

For maxima

$\ell = n\lambda$

$\ell_{min} = \lambda$

$= 0.29$ m



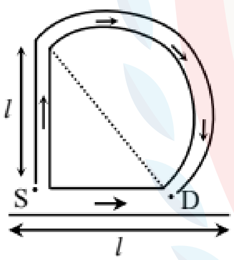
(R) Path difference :

$\Delta X = \ell + \pi R - \ell$

$\pi R = \frac{\pi \ell}{\sqrt{2}}$

For maxima $\frac{\pi \ell}{\sqrt{2}} = n\lambda$

$\Rightarrow \ell_{min} = \frac{\sqrt{2}\lambda}{\pi} = 0.13\text{m}$



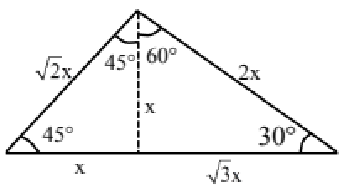
(S) $\Delta X = \left[\left(\sqrt{2}+2\right) = \left(\sqrt{3}+1\right)\right] x = 0.682x$

And $x + \sqrt{3}x = \ell \Rightarrow x = 0.366\ell$

$\Delta x = 0.249\ell$

For maxima $0.249\ell = n\lambda$

$\Rightarrow \ell_{min} = \lambda/0.249 \approx 1.19$



14. **(A)**

Sol. (P) Aurora Borealis is a phenomenon in which a natural light is seen in Earth's upper atomosphere caused by the charged particles from Sun colliding with atoms in the atmospheric. These collisions excite oxygen and nitrogen, which then emits light of different colours such as green, red and purple.

$(P) \rightarrow (5)$

(Q) Partially Polarised Sun light occurs due to the scattering of light by dust molecules in the atmosphere.

$(Q) \rightarrow (4)$

(R) Rainbow formation occurs due to the dispersion and reflection of light inside the water molecules in air.

$(R) \rightarrow (1)$

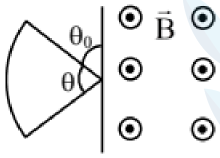
(S) Dark and bright fringes occur due to interference of light such as YDSE or diffraction.

$(S) \rightarrow (3)$

Ans. (A)

15. **(C)**

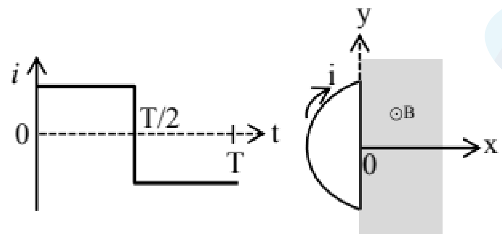
Sol. For a general loop of θ angle intilally making θ_0 angle with field.



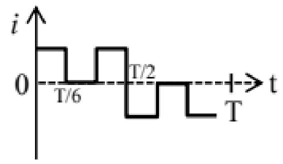
The graph starts at $t_{start} = \frac{\theta_0}{\omega} = \frac{\theta_0}{2\pi}T$

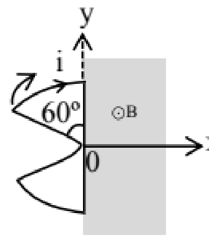
and remains constant for next $t_{constant} = \frac{\theta}{\omega} = \frac{\theta}{2\pi}T$

(P) $t_{start} = 0,\ t_{constant} = \frac{\pi}{2\pi}T = \frac{T}{2}$

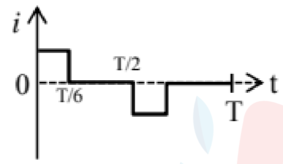


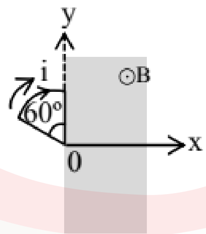
(Q) $t_{start} = 0, \frac{T}{3}$ $t_{constant} = \frac{\pi}{3.2\pi} T = \frac{T}{6}$



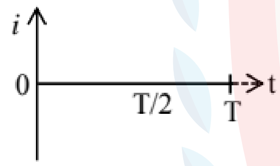


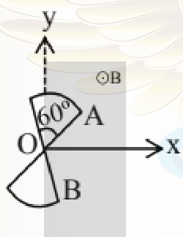
(R) $t_{start} = 0$ $t_{constant} = \frac{\pi}{3.2\pi} T = \frac{T}{6}$





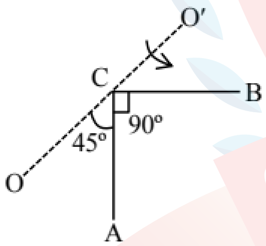
(S) Total emf of loop remains zero due to $V_{A0} = -V_{0B}$





16. **(A)**

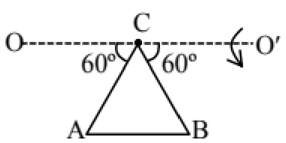
Sol. (P)



$$I = \frac{M\ell^2}{3}\sin^2 45° + \frac{M\ell^2}{3}\sin^2 45°$$

$$= \frac{M\ell^2}{3}$$

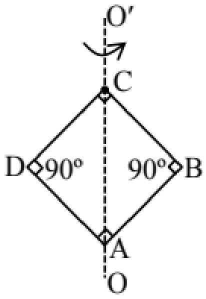
(Q)



$$I = \frac{M\ell^2}{3}\sin^2 60° + \frac{M\ell^2}{3}\sin^2 60°$$

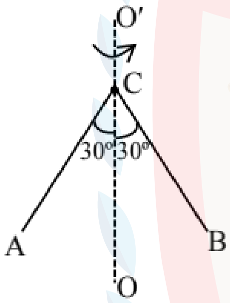
$$+\left(0 + M\left(\frac{\ell\sqrt{3}}{2}\right)^2\right)$$

$$I = \frac{M\ell^2}{2} + \frac{3}{4}M\ell^2 = \frac{5}{4}M\ell^2$$

(R) 

$$I = 4\left(\frac{M\ell^2}{3}\sin^2 45°\right)$$

$$= \frac{2}{3}M\ell^2$$

(S) 

$$I = 2\times\left(\frac{M\ell^2}{3}\sin^2 30°\right)$$

$$= \frac{M\ell^2}{6}$$