CAREERS 360

PREPARATION Series

JEE Advanced 2025

Question Paper (Paper 1 & 2)

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.

Q.1 Let $\mathbb{R}$ denote the set of all real numbers. Let $a_i, b_i \in \mathbb{R}$ for $i \in \{1, 2, 3\}$.
Define the functions $f: \mathbb{R} \to \mathbb{R}$, $g: \mathbb{R} \to \mathbb{R}$, and $h: \mathbb{R} \to \mathbb{R}$ by

$$f(x) = a_1 + 10x + a_2x^2 + a_3x^3 + x^4,$$
$$g(x) = b_1 + 3x + b_2x^2 + b_3x^3 + x^4,$$
$$h(x) = f(x+1) - g(x+2).$$

If $f(x) \neq g(x)$ for every $x \in \mathbb{R}$, then the coefficient of x^3 in $h(x)$ is

(A)	8
(B)	2
(C)	-4
(D)	-6

Q.2 Three students S_1, S_2, and S_3 are given a problem to solve. Consider the following events:

U: At least one of S_1, S_2, and S_3 can solve the problem,
V: S_1 can solve the problem, given that neither S_2 nor S_3 can solve the problem,
W: S_2 can solve the problem and S_3 cannot solve the problem,
T: S_3 can solve the problem.

For any event E, let $P(E)$ denote the probability of E. If

$$P(U) = \frac{1}{2}, \quad P(V) = \frac{1}{10}, \quad \text{and} \quad P(W) = \frac{1}{12},$$

then $P(T)$ is equal to

(A)	$\frac{13}{36}$	(B)	$\frac{1}{3}$	(C)	$\frac{19}{60}$	(D)	$\frac{1}{4}$

Q.3

Let $\mathbb{R}$ denote the set of all real numbers. Define the function $f: \mathbb{R} \to \mathbb{R}$ by

$$f(x) = \begin{cases} 2 - 2x^2 - x^2 \sin\frac{1}{x} & \text{if } x \neq 0, \\ 2 & \text{if } x = 0\,. \end{cases}$$

Then which one of the following statements is TRUE?

(A)	The function f is **NOT** differentiable at $x = 0$
(B)	There is a positive real number δ, such that f is a decreasing function on the interval $(0, \delta)$
(C)	For any positive real number δ, the function f is **NOT** an increasing function on the interval $(-\delta, 0)$
(D)	$x = 0$ is a point of local minima of f

Q.4

Consider the matrix

$$P = \begin{pmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{pmatrix}.$$

Let the transpose of a matrix X be denoted by X^T. Then the number of 3×3 invertible matrices Q with integer entries, such that

$$Q^{-1} = Q^T \text{ and } PQ = QP\,,$$

is

(A)	32	(B)	8	(C)	16	(D)	24

SECTION 2 (Maximum Marks: 12)

- This section contains **THREE (03)** 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 : -2 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 mark;
  choosing ONLY (B) will get +1 mark;
  choosing ONLY (D) will get +1 mark;
  choosing no option (i.e. the question is unanswered) will get 0 marks; and
  choosing any other combination of options will get -2 marks.

Q.5 Let L_1 be the line of intersection of the planes given by the equations

$$2x + 3y + z = 4 \text{ and } x + 2y + z = 5 .$$

Let L_2 be the line passing through the point $P(2, -1, 3)$ and parallel to L_1. Let M denote the plane given by the equation

$$2x + y - 2z = 6 .$$

Suppose that the line L_2 meets the plane M at the point Q. Let R be the foot of the perpendicular drawn from P to the plane M .

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

(A)	The length of the line segment PQ is $9\sqrt{3}$
(B)	The length of the line segment QR is 15
(C)	The area of ΔPQR is $\frac{3}{2}\sqrt{234}$
(D)	The acute angle between the line segments PQ and PR is $\cos^{-1}\left(\frac{1}{2\sqrt{3}}\right)$

Q.6

Let $\mathbb{N}$ denote the set of all natural numbers, and $\mathbb{Z}$ denote the set of all integers. Consider the functions $f: \mathbb{N} \to \mathbb{Z}$ and $g: \mathbb{Z} \to \mathbb{N}$ defined by

$$f(n) = \begin{cases} (n+1)/2 & \text{if } n \text{ is odd}, \\ (4-n)/2 & \text{if } n \text{ is even}, \end{cases}$$

and

$$g(n) = \begin{cases} 3+2n & \text{if } n \geq 0, \\ -2n & \text{if } n < 0. \end{cases}$$

Define $(g \circ f)(n) = g\big(f(n)\big)$ for all $n \in \mathbb{N}$, and $(f \circ g)(n) = f\big(g(n)\big)$ for all $n \in \mathbb{Z}$.

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

(A)	$g \circ f$ is **NOT** one-one and $g \circ f$ is **NOT** onto
(B)	$f \circ g$ is **NOT** one-one but $f \circ g$ is onto
(C)	g is one-one and g is onto
(D)	f is **NOT** one-one but f is onto

Q.7

Let $\mathbb{R}$ denote the set of all real numbers. Let $z_1 = 1 + 2i$ and $z_2 = 3i$ be two complex numbers, where $i = \sqrt{-1}$. Let

$$S = \{(x, y) \in \mathbb{R} \times \mathbb{R} : |x + iy - z_1| = 2|x + iy - z_2|\}.$$

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

(A)	S is a circle with centre $\left(-\frac{1}{3}, \frac{10}{3}\right)$
(B)	S is a circle with centre $\left(\frac{1}{3}, \frac{8}{3}\right)$
(C)	S is a circle with radius $\frac{\sqrt{2}}{3}$
(D)	S is a circle with radius $\frac{2\sqrt{2}}{3}$

SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- 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.

Q.8 Let the set of all relations R on the set $\{a, b, c, d, e, f\}$, such that R is reflexive and symmetric, and R contains exactly 10 elements, be denoted by $\mathcal{S}$.

Then the number of elements in $\mathcal{S}$ is _____.

Q.9 For any two points M and N in the XY-plane, let $\overrightarrow{MN}$ denote the vector from M to N, and $\vec{0}$ denote the zero vector. Let P, Q and R be three distinct points in the XY-plane. Let S be a point inside the triangle ΔPQR such that

$$\overrightarrow{SP} + 5\overrightarrow{SQ} + 6\overrightarrow{SR} = \vec{0}.$$

Let E and F be the mid-points of the sides PR and QR, respectively. Then the value of

$$\frac{\text{length of the line segment } EF}{\text{length of the line segment } ES}$$

is _____.

Q.10 Let S be the set of all seven-digit numbers that can be formed using the digits 0, 1 and 2. For example, 2210222 is in S, but 0210222 is **NOT** in S.
Then the number of elements x in S such that at least one of the digits 0 and 1 appears exactly twice in x, is equal to _____.

Q.11 Let α and β be the real numbers such that

$$\lim_{x\to 0} \frac{1}{x^3}\left(\frac{\alpha}{2}\int_0^x \frac{1}{1-t^2}\,dt + \beta x\cos x\right) = 2\,.$$

Then the value of $\alpha+\beta$ is _____.

Q.12 Let $\mathbb{R}$ denote the set of all real numbers. Let $f:\mathbb{R}\to\mathbb{R}$ be a function such that $f(x)>0$ for all $x\in\mathbb{R}$, and $f(x+y)=f(x)f(y)$ for all $x,y\in\mathbb{R}$.

Let the real numbers $a_1, a_2, \ldots, a_{50}$ be in an arithmetic progression. If $f(a_{31}) = 64 f(a_{25})$, and

$$\sum_{i=1}^{50} f(a_i) = 3(2^{25}+1)\,,$$

then the value of

$$\sum_{i=6}^{30} f(a_i)$$

is _____.

Q.13 For all $x>0$, let $y_1(x)$, $y_2(x)$, and $y_3(x)$ be the functions satisfying

$$\frac{dy_1}{dx} - (\sin x)^2\, y_1 = 0,\quad y_1(1)=5\,,$$
$$\frac{dy_2}{dx} - (\cos x)^2\, y_2 = 0,\quad y_2(1)=\frac{1}{3}\,,$$
$$\frac{dy_3}{dx} - \left(\frac{2-x^3}{x^3}\right) y_3 = 0,\quad y_3(1)=\frac{3}{5e}\,,$$

respectively. Then

$$\lim_{x\to 0^+} \frac{y_1(x)y_2(x)y_3(x)+2x}{e^{3x}\sin x}$$

is equal to _____.

SECTION 4 (Maximum Marks: 12)

- This section contains **THREE (03)** 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.

Q.14 Consider the following frequency distribution:

Value	4	5	8	9	6	12	11
Frequency	5	f_1	f_2	2	1	1	3

Suppose that the sum of the frequencies is 19 and the median of this frequency distribution is 6.

For the given frequency distribution, let α denote the mean deviation about the mean, β denote the mean deviation about the median, and σ^2 denote the variance.

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

List-I	**List-II**
(P) $7f_1 + 9f_2$ is equal to	(1) 146
(Q) 19α is equal to	(2) 47
(R) 19β is equal to	(3) 48
(S) $19\sigma^2$ is equal to	(4) 145
	(5) 55

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

Q.15

Let $\mathbb{R}$ denote the set of all real numbers. For a real number x, let $[x]$ denote the greatest integer less than or equal to x. Let n denote a natural number.

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

List-I	**List-II**
(P) The minimum value of n for which the function $f(x) = \left[\frac{10x^3 - 45x^2 + 60x + 35}{n}\right]$ is continuous on the interval $[1, 2]$, is	(1) 8
(Q) The minimum value of n for which $g(x) = (2n^2 - 13n - 15)(x^3 + 3x)$, $x \in \mathbb{R}$, is an increasing function on $\mathbb{R}$, is	(2) 9
(R) The smallest natural number n which is greater than 5, such that $x = 3$ is a point of local minima of $h(x) = (x^2 - 9)^n(x^2 + 2x + 3)$, is	(3) 5
(S) Number of $x_0 \in \mathbb{R}$ such that $l(x) = \sum_{k=0}^{4}\left(\sin\lvert x - k\rvert + \cos\left\lvert x - k + \frac{1}{2}\right\rvert\right)$, $x \in \mathbb{R}$, is **NOT** differentiable at x_0, is	(4) 6
	(5) 10

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

Q.16

Let $\vec{w} = \hat{\imath} + \hat{\jmath} - 2\hat{k}$, and $\vec{u}$ and $\vec{v}$ be two vectors, such that $\vec{u} \times \vec{v} = \vec{w}$ and $\vec{v} \times \vec{w} = \vec{u}$. Let α, β, γ, and t be real numbers such that

$\vec{u} = \alpha\hat{\imath} + \beta\hat{\jmath} + \gamma\hat{k}$, $-t\,\alpha + \beta + \gamma = 0$, $\alpha - t\,\beta + \gamma = 0$, and $\alpha + \beta - t\,\gamma = 0$.

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

List-I	**List-II**
(P) $\lvert\vec{v}\rvert^2$ is equal to	(1) 0
(Q) If $\alpha = \sqrt{3}$, then γ^2 is equal to	(2) 1
(R) If $\alpha = \sqrt{3}$, then $(\beta + \gamma)^2$ is equal to	(3) 2
(S) If $\alpha = \sqrt{2}$, then $t + 3$ is equal to	(4) 3
	(5) 5

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

END OF THE QUESTION PAPER

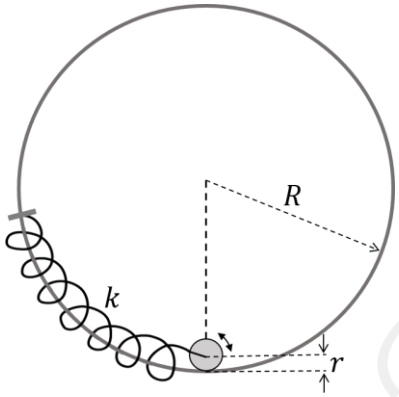
SECTION 1 (Maximum Marks: 12)

- 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.

Q.1

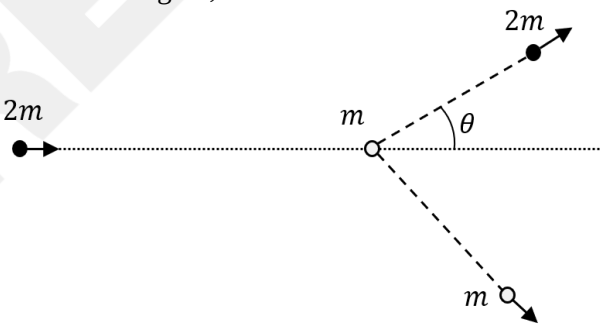
The center of a disk of radius r and mass m is attached to a spring of spring constant k, inside a ring of radius $R > r$ as shown in the figure. The other end of the spring is attached on the periphery of the ring. Both the ring and the disk are in the same vertical plane. The disk can only roll along the inside periphery of the ring, without slipping. The spring can only be stretched or compressed along the periphery of the ring, following the Hooke's law. In equilibrium, the disk is at the bottom of the ring. Assuming small displacement of the disc, the time period of oscillation of center of mass of the disk is written as $T = \frac{2\pi}{\omega}$. The correct expression for ω is (g is the acceleration due to gravity):



(A)	$\sqrt{\frac{2}{3}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$	(B)	$\sqrt{\frac{2g}{3(R-r)}+\frac{k}{m}}$
(C)	$\sqrt{\frac{1}{6}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$	(D)	$\sqrt{\frac{1}{4}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$

Q.2

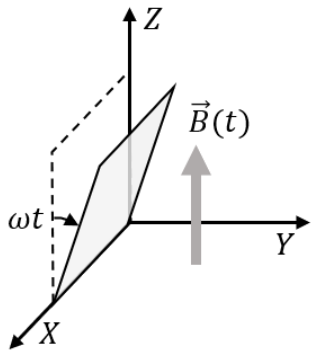
In a scattering experiment, a particle of mass $2m$ collides with another particle of mass m, which is initially at rest. Assuming the collision to be perfectly elastic, the maximum angular deviation θ of the heavier particle, as shown in the figure, in radians is:



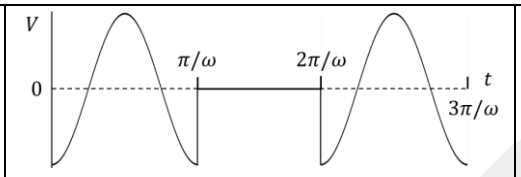
(A)	π	(B)	$\tan^{-1}\left(\frac{1}{2}\right)$	(C)	$\frac{\pi}{3}$	(D)	$\frac{\pi}{6}$

Q.3

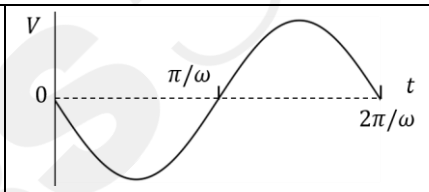
A conducting square loop initially lies in the XZ plane with its lower edge hinged along the X-axis. Only in the region $y \geq 0$, there is a time dependent magnetic field pointing along the Z-direction, $\vec{B}(t) = B_0(\cos \omega t)\hat{k}$, where B_0 is a constant. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts rotating with constant angular speed ω about the X axis in the clockwise direction as viewed from the $+X$ axis (as shown in the figure). Ignoring self-inductance of the loop and gravity, which of the following plots correctly represents the induced e.m.f. (V) in the loop as a function of time:



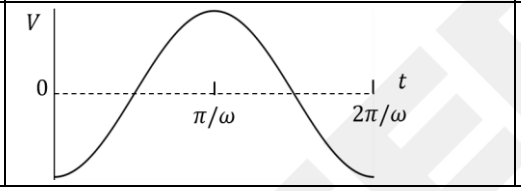
(A)



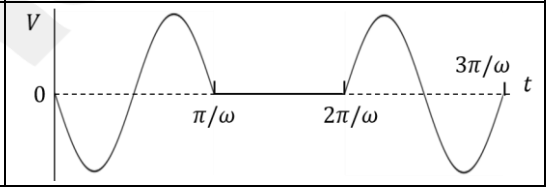
(B)



(C)



(D)



Q.4

Figure 1 shows the configuration of main scale and Vernier scale before measurement. Fig. 2 shows the configuration corresponding to the measurement of diameter D of a tube. The measured value of D is:

Fig. 1

Fig. 2

(A)	0.12 cm
(B)	0.11 cm
(C)	0.13 cm
(D)	0.14 cm

SECTION 2 (Maximum Marks: 12)

- This section contains **THREE (03)** 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;
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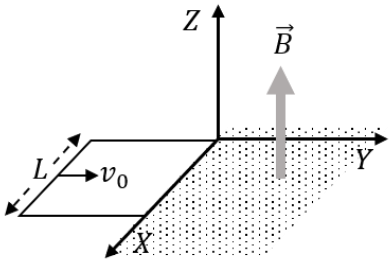
  Partial Marks : $+2$ If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
  Partial Marks : $+1$ If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
  Negative Marks : -2 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 mark;
  choosing ONLY (B) will get +1 mark;
  choosing ONLY (D) will get +1 mark;
  choosing no option (i.e. the question is unanswered) will get 0 marks; and
  choosing any other combination of options will get -2 marks.

Q.5

A conducting square loop of side L, mass M and resistance R is moving in the XY plane with its edges parallel to the X and Y axes. The region $y \geq 0$ has a uniform magnetic field, $\vec{B} = B_0\hat{k}$. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts to enter the magnetic field with an initial velocity $v_0\hat{j}$ m/s, as shown in the figure. Considering the quantity $K = \frac{B_0^2L^2}{RM}$ in appropriate units, ignoring self-inductance of the loop and gravity, which of the following statements is/are correct:



(A)	If $v_0 = 1.5KL$, the loop will stop before it enters completely inside the region of magnetic field.
(B)	When the complete loop is inside the region of magnetic field, the net force acting on the loop is zero.
(C)	If $v_0 = \frac{KL}{10}$, the loop comes to rest at $t = \left(\frac{1}{K}\right)\ln\left(\frac{5}{2}\right)$.
(D)	If $v_0 = 3KL$, the complete loop enters inside the region of magnetic field at time $t = \left(\frac{1}{K}\right)\ln\left(\frac{3}{2}\right)$.

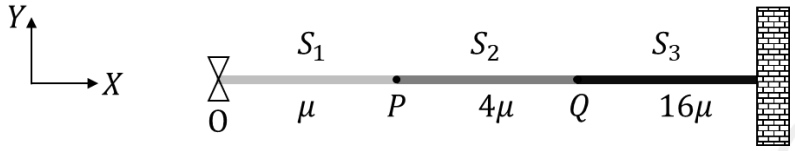
Q.6

Length, breadth and thickness of a strip having a uniform cross section are measured to be 10.5 cm, 0.05 mm, and 6.0 μm, respectively. Which of the following option(s) give(s) the volume of the strip in cm^3 with correct significant figures:

(A)	3.2×10^{-5}	(B)	32.0×10^{-6}	(C)	3.0×10^{-5}	(D)	3×10^{-5}

Q.7

Consider a system of three connected strings, S_1, S_2 and S_3 with uniform linear mass densities μ kg/m, 4μ kg/m and 16μ kg/m, respectively, as shown in the figure. S_1 and S_2 are connected at the point P, whereas S_2 and S_3 are connected at the point Q, and the other end of S_3 is connected to a wall. A wave generator O is connected to the free end of S_1. The wave from the generator is represented by $y = y_0 \cos(\omega t - kx)$ cm, where y_0, ω and k are constants of appropriate dimensions. Which of the following statements is/are correct:



(A)	When the wave reflects from P for the first time, the reflected wave is represented by $y = \alpha_1 y_0 \cos(\omega t + kx + \pi)$ cm, where α_1 is a positive constant.
(B)	When the wave transmits through P for the first time, the transmitted wave is represented by $y = \alpha_2 y_0 \cos(\omega t - kx)$ cm, where α_2 is a positive constant.
(C)	When the wave reflects from Q for the first time, the reflected wave is represented by $y = \alpha_3 y_0 \cos(\omega t - kx + \pi)$ cm, where α_3 is a positive constant.
(D)	When the wave transmits through Q for the first time, the transmitted wave is represented by $y = \alpha_4 y_0 \cos(\omega t - 4kx)$ cm, where α_4 is a positive constant.

SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- 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.

Q.8 A person sitting inside an elevator performs a weighing experiment with an object of mass 50 kg. Suppose that the variation of the height y (in m) of the elevator, from the ground, with time t (in s) is given by $y = 8\left[1 + \sin\left(\frac{2\pi t}{T}\right)\right]$, where $T = 40\pi$ s. Taking acceleration due to gravity, $g = 10$ m/s^2, the maximum variation of the object's weight (in N) as observed in the experiment is ____

Q.9 A cube of unit volume contains 35×10^7 photons of frequency 10^{15} Hz. If the energy of all the photons is viewed as the average energy being contained in the electromagnetic waves within the same volume, then the amplitude of the magnetic field is $\alpha \times 10^{-9}$ T. Taking permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Tm/A, Planck's constant $h = 6 \times 10^{-34}$Js and $\pi = \frac{22}{7}$, the value of α is____

Q.10 Two identical plates P and Q, radiating as perfect black bodies, are kept in vacuum at constant absolute temperatures T_P and T_Q, respectively, with $T_Q < T_P$, as shown in Fig. 1. The radiated power transferred per unit area from P to Q is W_0. Subsequently, two more plates, identical to P and Q, are introduced between P and Q, as shown in Fig. 2. Assume that heat transfer takes place only between adjacent plates. If the power transferred per unit area in the direction from P to Q (Fig. 2) in the steady state is W_S, then the ratio $\frac{W_0}{W_S}$ is ___

Fig. 1

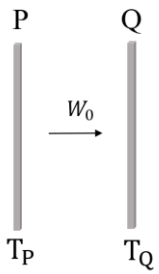
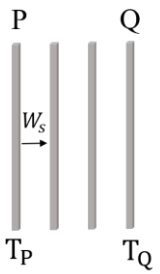
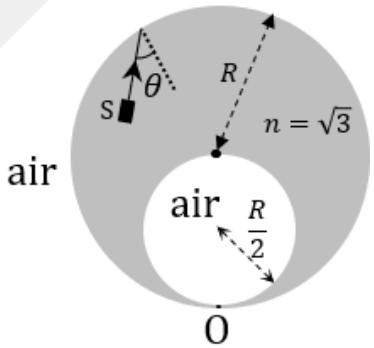


Fig. 2



Q.11 A solid glass sphere of refractive index $n = \sqrt{3}$ and radius R contains a spherical air cavity of radius $\frac{R}{2}$, as shown in the figure. A very thin glass layer is present at the point O so that the air cavity (refractive index $n = 1$) remains inside the glass sphere. An unpolarized, unidirectional and monochromatic light source S emits a light ray from a point inside the glass sphere towards the periphery of the glass sphere. If the light is reflected from the point O and is fully polarized, then the angle of incidence at the inner surface of the glass sphere is θ. The value of $\sin\theta$ is ____



Q.12 A single slit diffraction experiment is performed to determine the slit width using the equation, $\frac{bd}{D} = m\lambda$, where b is the slit width, D the shortest distance between the slit and the screen, d the distance between the m^{th} diffraction maximum and the central maximum, and λ is the wavelength. D and d are measured with scales of least count of 1 cm and 1 mm, respectively. The values of λ and m are known precisely to be 600 nm and 3, respectively. The absolute error (in μm) in the value of b estimated using the diffraction maximum that occurs for $m = 3$ with $d =$ 5 mm and $D = 1$ m is ___

Q.13 Consider an electron in the $n = 3$ orbit of a hydrogen-like atom with atomic number Z. At absolute temperature T, a neutron having thermal energy $k_{\text{B}}T$ has the same de Broglie wavelength as that of this electron. If this temperature is given by $T = \frac{Z^2h^2}{\alpha\pi^2 a_0^2 m_{\text{N}} k_{\text{B}}}$, (where h is the Planck's constant, k_B is the Boltzmann constant, m_{N} is the mass of the neutron and a_0 is the first Bohr radius of hydrogen atom) then the value of α is ___

SECTION 4 (Maximum Marks: 12)

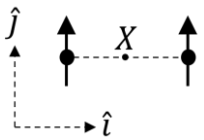
- This section contains **THREE (03)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options 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.

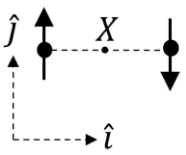
Q.14

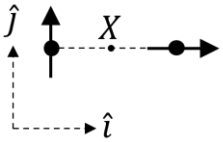
List-I shows four configurations, each consisting of a pair of ideal electric dipoles. Each dipole has a dipole moment of magnitude p, oriented as marked by arrows in the figures. In all the configurations the dipoles are fixed such that they are at a distance $2r$ apart along the x direction. The midpoint of the line joining the two dipoles is X. The possible resultant electric fields $\vec{E}$ at X are given in List-II.

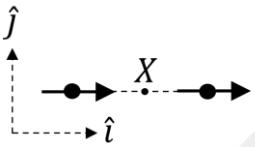
Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

List-I

(P) 

(Q) 

(R) 

(S) 

List-II

(1) $\vec{E} = 0$

(2) $\vec{E} = -\frac{p}{2\pi\epsilon_0 r^3}\hat{j}$

(3) $\vec{E} = -\frac{p}{4\pi\epsilon_0 r^3}(\hat{\imath} - \hat{j})$

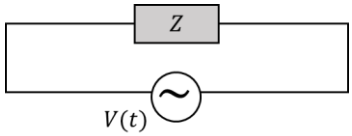
(4) $\vec{E} = \frac{p}{4\pi\epsilon_0 r^3}(2\hat{\imath} - \hat{j})$

(5) $\vec{E} = \frac{p}{\pi\epsilon_0 r^3}\hat{\imath}$

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

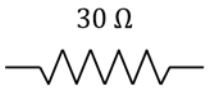
Q.15

A circuit with an electrical load having impedance Z is connected with an AC source as shown in the diagram. The source voltage varies in time as $V(t) = 300\sin(400t)$ V, where t is time in s. List-I shows various options for the load. The possible currents $i(t)$ in the circuit as a function of time are given in List-II.

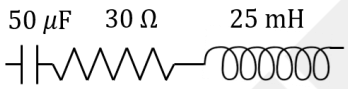


Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

List-I

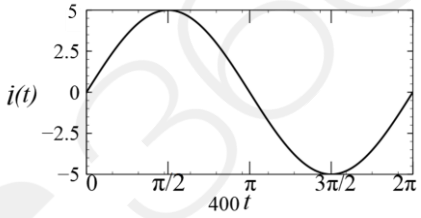
(P) 

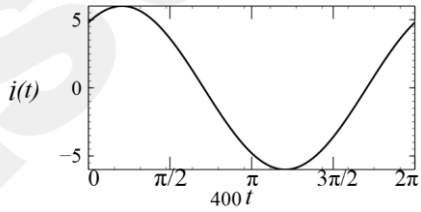
(Q) 

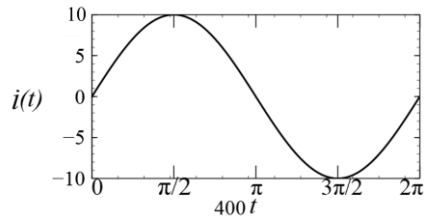
(R) 

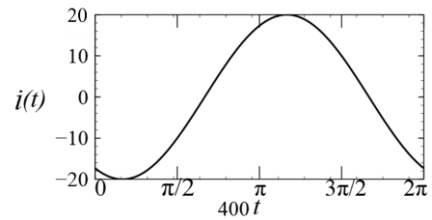
(S) 

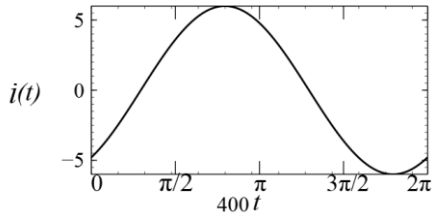
List-II

(1) 

(2) 

(3) 

(4) 

(5) 

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

Q.16 List-I shows various functional dependencies of energy (E) on the atomic number (Z). Energies associated with certain phenomena are given in List-II.

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

List-I	**List-II**
(P) $E \propto Z^2$	(1) energy of characteristic x-rays
(Q) $E \propto (Z-1)^2$	(2) electrostatic part of the nuclear binding energy for stable nuclei with mass numbers in the range 30 to 170
(R) $E \propto Z(Z-1)$	(3) energy of continuous x-rays
(S) E is practically independent of Z	(4) average nuclear binding energy per nucleon for stable nuclei with mass number in the range 30 to 170
	(5) energy of radiation due to electronic transitions from hydrogen-like atoms

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

END OF THE QUESTION PAPER

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.

Q.1 The heating of NH_4NO_2 at 60–70 °C and NH_4NO_3 at 200–250 °C is associated with the formation of nitrogen containing compounds **X** and **Y**, respectively. **X** and **Y**, respectively, are

(A)	N_2 and N_2O
(B)	NH_3 and NO_2
(C)	NO and N_2O
(D)	N_2 and NH_3

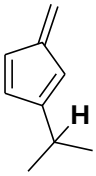
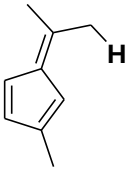
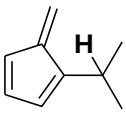
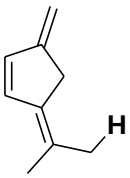
Q.2 The correct order of the wavelength maxima of the absorption band in the ultraviolet-visible region for the given complexes is

(A)	$[Co(CN)_6]^{3-} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_5(Cl)]^{2+}$
(B)	$[Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-}$
(C)	$[Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+}$
(D)	$[Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+}$

Q.3 One of the products formed from the reaction of permanganate ion with iodide ion in neutral aqueous medium is

(A)	I_2	(B)	IO_3^-	(C)	IO_4^-	(D)	IO_2^-

Q.4 Consider the depicted hydrogen (**H**) in the hydrocarbons given below. The most acidic hydrogen (**H**) is

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

SECTION 2 (Maximum Marks: 12)

- This section contains **THREE (03)** 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 : -2 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 mark;
  choosing ONLY (B) will get +1 mark;
  choosing ONLY (D) will get +1 mark;
  choosing no option (i.e. the question is unanswered) will get 0 marks; and
  choosing any other combination of options will get -2 marks.

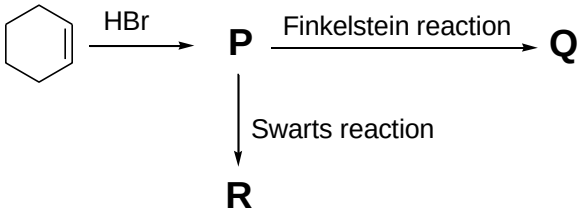
Q.5 Regarding the molecular orbital (MO) energy levels for homonuclear diatomic molecules, the **INCORRECT** statement(s) is(are)

(A)	Bond order of Ne_2 is zero.
(B)	The highest occupied molecular orbital (HOMO) of F_2 is σ-type.
(C)	Bond energy of O_2^+ is smaller than the bond energy of O_2.
(D)	Bond length of Li_2 is larger than the bond length of B_2.

Q.6 The pair(s) of diamagnetic ions is(are)

(A)	La^{3+}, Ce^{4+}
(B)	Yb^{2+}, Lu^{3+}
(C)	La^{2+}, Ce^{3+}
(D)	Yb^{3+}, Lu^{2+}

Q.7 For the reaction sequence given below, the correct statement(s) is(are)



(In the options, X is any atom other than carbon and hydrogen, and it is different in **P**, **Q** and **R**)

(A)	C–X bond length in **P**, **Q** and **R** follows the order **Q** > **R** > **P**.
(B)	C–X bond enthalpy in **P**, **Q** and **R** follows the order **R** > **P** > **Q**.
(C)	Relative reactivity toward S_N2 reaction in **P**, **Q** and **R** follows the order **P** > **R** > **Q**.
(D)	pK_a value of the conjugate acids of the leaving groups in **P**, **Q** and **R** follows the order **R** > **Q** > **P**.

SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- 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.

Q.8 In an electrochemical cell, dichromate ions in aqueous acidic medium are reduced to Cr^{3+}. The current (in amperes) that flows through the cell for 48.25 minutes to produce 1 mole of Cr^{3+} is _____.

Use: 1 Faraday $= 96500$ C mol^{-1}

Q.9 At 25 ℃, the concentration of H^+ ions in 1.00×10^{-3} M aqueous solution of a weak monobasic acid having acid dissociation constant (K_a) of 4.00×10^{-11} is $\boldsymbol{X} \times 10^{-7}$ M. The value of $\boldsymbol{X}$ is _____.

Use: Ionic product of water (K_w) $= 1.00 \times 10^{-14}$ at 25 ℃

Q.10 Molar volume (V_m) of a van der Waals gas can be calculated by expressing the van der Waals equation as a cubic equation with V_m as the variable. The ratio (in mol dm^{-3}) of the coefficient of V_m^2 to the coefficient of V_m for a gas having van der Waals constants $a = 6.0$ dm^6 atm mol^{-2} and $b = 0.060$ dm^3 mol^{-1} at 300 K and 300 atm is _____.

Use: Universal gas constant (R) $= 0.082$ dm^3 atm mol^{-1} K^{-1}

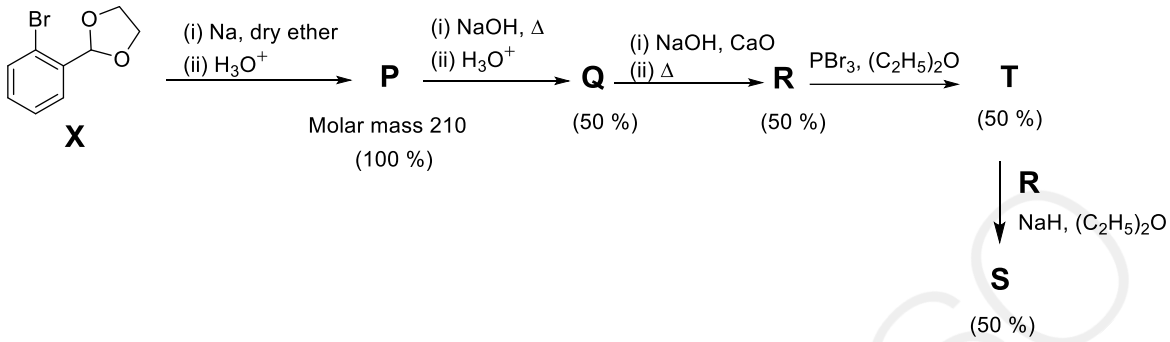
Q.11 Considering ideal gas behavior, the expansion work done (in kJ) when 144 g of water is electrolyzed completely under constant pressure at 300 K is _____.

Use: Universal gas constant (R) $= 8.3$ J K^{-1} mol^{-1}; Atomic mass (in amu): H = 1, O = 16

Q.12 The monomer (**X**) involved in the synthesis of Nylon 6,6 gives positive carbylamine test. If 10 moles of **X** are analyzed using Dumas method, the amount (in grams) of nitrogen gas evolved is _____.

Use: Atomic mass of N (in amu) = 14

Q.13 The reaction sequence given below is carried out with 16 moles of **X**. The yield of the major product in each step is given below the product in parentheses. The amount (in grams) of **S** produced is_____.



Use: Atomic mass (in amu): H = 1, C = 12, O = 16, Br = 80

SECTION 4 (Maximum Marks: 12)

- This section contains **THREE (03)** 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.

Q.14 The correct match of the group reagents in **List-I** for precipitating the metal ion given in **List-II** from solutions, is

List-I	**List-II**
(P) Passing H_2S in the presence of NH_4OH	(1) Cu^{2+}
(Q) $(NH_4)_2CO_3$ in the presence of NH_4OH	(2) Al^{3+}
(R) NH_4OH in the presence of NH_4Cl	(3) Mn^{2+}
(S) Passing H_2S in the presence of dilute HCl	(4) Ba^{2+}
	(5) Mg^{2+}

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

Q.15 The major products obtained from the reactions in **List-II** are the reactants for the named reactions mentioned in **List-I**. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

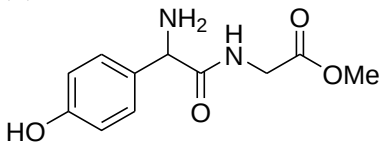
List-I	**List-II**
(P) Stephen reaction	(1) Toluene $\xrightarrow{\text{(i) } CrO_2Cl_2/CS_2,\ \text{(ii) } H_3O^+}$
(Q) Sandmeyer reaction	(2) Benzoic acid $\xrightarrow{\text{(i) } PCl_5,\ \text{(ii) } NH_3,\ \text{(iii) } P_4O_{10},\ \Delta}$
(R) Hoffmann bromamide degradation reaction	(3) Nitrobenzene $\xrightarrow{\text{(i) Fe, HCl, (ii) HCl, } NaNO_2,\ (273\text{-}278\ K),\ H_2O}$
(S) Cannizzaro reaction	(4) Toluene $\xrightarrow{\text{(i) } Cl_2/h\nu,\ H_2O,\ \text{(ii) Tollen's reagent, (iii) } SO_2Cl_2,\ \text{(iv) } NH_3}$
	(5) Aniline $\xrightarrow{\text{(i) } (CH_3CO)_2O,\ \text{Pyridine, (ii) } HNO_3,\ H_2SO_4,\ 288\ K,\ \text{(iii) aq. NaOH}}$

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

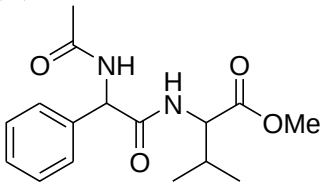
Q.16 Match the compounds in **List-I** with the appropriate observations in **List-II** and choose the correct option.

List-I

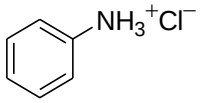
(P)



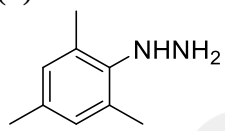
(Q)



(R)



(S)



List-II

(1) Reaction with phenyl diazonium salt gives yellow dye.

(2) Reaction with ninhydrin gives purple color and it also reacts with $FeCl_3$ to give violet color.

(3) Reaction with glucose will give corresponding hydrazone.

(4) Lassiagne extract of the compound treated with dilute HCl followed by addition of aqueous $FeCl_3$ gives blood red color.

(5) After complete hydrolysis, it will give ninhydrin test and it **DOES NOT** give positive phthalein dye test.

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

END OF THE QUESTION PAPER

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.

Q.1 Let x_0 be the real number such that $e^{x_0} + x_0 = 0$. For a given real number α, define

$$g(x) = \frac{3xe^x + 3x - \alpha e^x - \alpha x}{3(e^x + 1)}$$

for all real numbers x.

Then which one of the following statements is TRUE?

(A)	For $\alpha = 2$, $\lim\limits_{x \to x_0} \left\lvert \frac{g(x) + e^{x_0}}{x - x_0} \right\rvert = 0$
(B)	For $\alpha = 2$, $\lim\limits_{x \to x_0} \left\lvert \frac{g(x) + e^{x_0}}{x - x_0} \right\rvert = 1$
(C)	For $\alpha = 3$, $\lim\limits_{x \to x_0} \left\lvert \frac{g(x) + e^{x_0}}{x - x_0} \right\rvert = 0$
(D)	For $\alpha = 3$, $\lim\limits_{x \to x_0} \left\lvert \frac{g(x) + e^{x_0}}{x - x_0} \right\rvert = \frac{2}{3}$

Q.2 Let $\mathbb{R}$ denote the set of all real numbers. Then the area of the region

$$\left\{(x, y) \in \mathbb{R} \times \mathbb{R} : x > 0, y > \frac{1}{x}, 5x - 4y - 1 > 0, 4x + 4y - 17 < 0\right\}$$

is

(A)	$\frac{17}{16} - \log_e 4$	(B)	$\frac{33}{8} - \log_e 4$
(C)	$\frac{57}{8} - \log_e 4$	(D)	$\frac{17}{2} - \log_e 4$

Q.3 The total number of real solutions of the equation

$$\theta = \tan^{-1}(2\tan\theta) - \frac{1}{2}\sin^{-1}\left(\frac{6\tan\theta}{9+\tan^2\theta}\right)$$

is

(Here, the inverse trigonometric functions $\sin^{-1}x$ and $\tan^{-1}x$ assume values in $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$ and $\left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$, respectively.)

(A)	1	(B)	2	(C)	3	(D)	5

Q.4 Let S denote the locus of the point of intersection of the pair of lines

$$4x - 3y = 12\alpha,$$
$$4\alpha x + 3\alpha y = 12,$$

where α varies over the set of non-zero real numbers. Let T be the tangent to S passing through the points $(p, 0)$ and $(0, q)$, $q > 0$, and parallel to the line $4x - \frac{3}{\sqrt{2}}y = 0$.

Then the value of pq is

(A)	$-6\sqrt{2}$	(B)	$-3\sqrt{2}$	(C)	$-9\sqrt{2}$	(D)	$-12\sqrt{2}$

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 : -2 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 mark;
  choosing ONLY (B) will get +1 mark;
  choosing ONLY (D) will get +1 mark;
  choosing no option (i.e. the question is unanswered) will get 0 marks; and
  choosing any other combination of options will get -2 marks.

Q.5

Let $I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ and $P = \begin{pmatrix} 2 & 0 \\ 0 & 3 \end{pmatrix}$. Let $Q = \begin{pmatrix} x & y \\ z & 4 \end{pmatrix}$ for some non-zero real numbers x, y, and z, for which there is a 2×2 matrix R with all entries being non-zero real numbers, such that $QR = RP$.

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

(A)	The determinant of $Q - 2I$ is zero
(B)	The determinant of $Q - 6I$ is 12
(C)	The determinant of $Q - 3I$ is 15
(D)	$yz = 2$

Q.6

Let S denote the locus of the mid-points of those chords of the parabola $y^2 = x$, such that the area of the region enclosed between the parabola and the chord is $\frac{4}{3}$. Let $\mathcal{R}$ denote the region lying in the first quadrant, enclosed by the parabola $y^2 = x$, the curve S, and the lines $x = 1$ and $x = 4$.

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

(A)	$(4, \sqrt{3}) \in S$
(B)	$(5, \sqrt{2}) \in S$
(C)	Area of $\mathcal{R}$ is $\frac{14}{3} - 2\sqrt{3}$
(D)	Area of $\mathcal{R}$ is $\frac{14}{3} - \sqrt{3}$

Q.7

Let $P(x_1, y_1)$ and $Q(x_2, y_2)$ be two distinct points on the ellipse

$$\frac{x^2}{9} + \frac{y^2}{4} = 1$$

such that $y_1 > 0$, and $y_2 > 0$. Let C denote the circle $x^2 + y^2 = 9$, and M be the point $(3, 0)$.

Suppose the line $x = x_1$ intersects C at R, and the line $x = x_2$ intersects C at S, such that the y-coordinates of R and S are positive. Let $\angle ROM = \frac{\pi}{6}$ and $\angle SOM = \frac{\pi}{3}$, where O denotes the origin $(0, 0)$. Let $|XY|$ denote the length of the line segment XY.

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

(A)	The equation of the line joining P and Q is $2x + 3y = 3(1 + \sqrt{3})$
(B)	The equation of the line joining P and Q is $2x + y = 3(1 + \sqrt{3})$
(C)	If $N_2 = (x_2, 0)$, then $3\|N_2Q\| = 2\|N_2S\|$
(D)	If $N_1 = (x_1, 0)$, then $9\|N_1P\| = 4\|N_1R\|$

Q.8

Let $\mathbb{R}$ denote the set of all real numbers. Let $f: \mathbb{R} \to \mathbb{R}$ be defined by

$$f(x) = \begin{cases} \frac{6x + \sin x}{2x + \sin x} & \text{if } x \neq 0, \\ \frac{7}{3} & \text{if } x = 0. \end{cases}$$

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

(A)	The point $x = 0$ is a point of local maxima of f
(B)	The point $x = 0$ is a point of local minima of f
(C)	Number of points of local maxima of f in the interval $[\pi, 6\pi]$ is 3
(D)	Number of points of local minima of f in the interval $[2\pi, 4\pi]$ is 1

SECTION 3 (Maximum Marks: 32)

- This section contains **EIGHT (08)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- 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.

Q.9 Let $y(x)$ be the solution of the differential equation

$$x^2\frac{dy}{dx}+xy=x^2+y^2,\quad x>\frac{1}{e},$$

satisfying $y(1)=0$. Then the value of $2\frac{(y(e))^2}{y(e^2)}$ is _____.

Q.10 Let $a_0, a_1, \ldots, a_{23}$ be real numbers such that

$$\left(1+\frac{2}{5}x\right)^{23}=\sum_{i=0}^{23}a_i x^i$$

for every real number x. Let a_r be the largest among the numbers a_j for $0\le j\le 23$.
Then the value of r is _____.

Q.11 A factory has a total of three manufacturing units, $M_1, M_2,$ and M_3, which produce bulbs independent of each other. The units $M_1, M_2,$ and M_3 produce bulbs in the proportions of $2:2:1$, respectively. It is known that 20% of the bulbs produced in the factory are defective. It is also known that, of all the bulbs produced by M_1, 15% are defective. Suppose that, if a randomly chosen bulb produced in the factory is found to be defective, the probability that it was produced by M_2 is $\frac{2}{5}$.

If a bulb is chosen randomly from the bulbs produced by M_3, then the probability that it is defective is _____.

Q.12 Consider the vectors

$$\vec{x}=\hat{\imath}+2\hat{\jmath}+3\hat{k},\quad \vec{y}=2\hat{\imath}+3\hat{\jmath}+\hat{k},\quad \text{and}\quad \vec{z}=3\hat{\imath}+\hat{\jmath}+2\hat{k}.$$

For two distinct positive real numbers α and β, define

$$\vec{X}=\alpha\vec{x}+\beta\vec{y}-\vec{z},\quad \vec{Y}=\alpha\vec{y}+\beta\vec{z}-\vec{x},\quad \text{and}\quad \vec{Z}=\alpha\vec{z}+\beta\vec{x}-\vec{y}.$$

If the vectors $\vec{X}, \vec{Y},$ and $\vec{Z}$ lie in a plane, then the value of $\alpha+\beta-3$ is_____.

Q.13 For a non-zero complex number z, let $\arg(z)$ denote the principal argument of z, with $-\pi < \arg(z) \leq \pi$. Let ω be the cube root of unity for which $0 < \arg(\omega) < \pi$. Let

$$\alpha = \arg\left(\sum_{n=1}^{2025} (-\omega)^n\right).$$

Then the value of $\frac{3\alpha}{\pi}$ is _____.

Q.14 Let $\mathbb{R}$ denote the set of all real numbers. Let $f: \mathbb{R} \to \mathbb{R}$ and $g: \mathbb{R} \to (0, 4)$ be functions defined by

$$f(x) = \log_e(x^2 + 2x + 4), \text{ and } g(x) = \frac{4}{1 + e^{-2x}}.$$

Define the composite function $f \circ g^{-1}$ by $(f \circ g^{-1})(x) = f\left(g^{-1}(x)\right)$, where g^{-1} is the inverse of the function g.

Then the value of the derivative of the composite function $f \circ g^{-1}$ at $x = 2$ is _____.

Q.15 Let

$$\alpha = \frac{1}{\sin 60^\circ \sin 61^\circ} + \frac{1}{\sin 62^\circ \sin 63^\circ} + \cdots + \frac{1}{\sin 118^\circ \sin 119^\circ}.$$

Then the value of

$$\left(\frac{\operatorname{cosec} 1^\circ}{\alpha}\right)^2$$

is _____.

Q.16 If

$$\alpha = \int_{\frac{1}{2}}^{2} \frac{\tan^{-1} x}{2x^2 - 3x + 2}\, dx,$$

then the value of $\sqrt{7} \tan\left(\frac{2\alpha\sqrt{7}}{\pi}\right)$ is _____.

(Here, the inverse trigonometric function $\tan^{-1} x$ assumes values in $\left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$.)

END OF THE QUESTION PAPER

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.

Q.1

A temperature difference can generate e.m.f. in some materials. Let S be the e.m.f. produced per unit temperature difference between the ends of a wire, σ the electrical conductivity and κ the thermal conductivity of the material of the wire. Taking M, L, T, I and K as dimensions of mass, length, time, current and temperature, respectively, the dimensional formula of the quantity $Z = \frac{S^2\sigma}{\kappa}$ is:

(A)	$[M^0L^0T^0I^0K^0]$	(B)	$[M^0L^0T^0I^0K^{-1}]$
(C)	$[M^1L^2T^{-2}I^{-1}K^{-1}]$	(D)	$[M^1L^2T^{-4}I^{-1}K^{-1}]$

Q.2

Two co-axial conducting cylinders of same length ℓ with radii $\sqrt{2}R$ and $2R$ are kept, as shown in Fig. 1. The charge on the inner cylinder is Q and the outer cylinder is grounded. The annular region between the cylinders is filled with a material of dielectric constant $\kappa = 5$. Consider an imaginary plane of the same length ℓ at a distance R from the common axis of the cylinders. This plane is parallel to the axis of the cylinders. The cross-sectional view of this arrangement is shown in Fig. 2. Ignoring edge effects, the flux of the electric field through the plane is (ϵ_0 is the permittivity of free space):

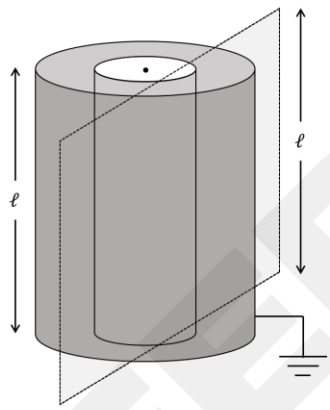


Fig. 1

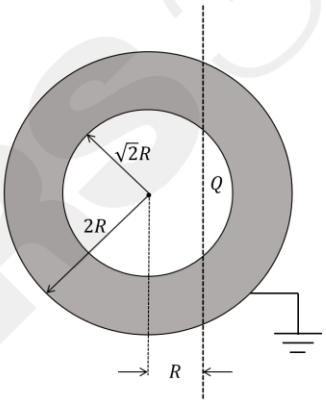


Fig. 2

(A)	$\frac{Q}{30\epsilon_0}$	(B)	$\frac{Q}{15\epsilon_0}$	(C)	$\frac{Q}{60\epsilon_0}$	(D)	$\frac{Q}{120\epsilon_0}$

Q.3

As shown in the figures, a uniform rod OO' of length l is hinged at the point O and held in place vertically between two walls using two massless springs of same spring constant. The springs are connected at the midpoint and at the top-end (O') of the rod, as shown in Fig. 1 and the rod is made to oscillate by a small angular displacement. The frequency of oscillation of the rod is f_1. On the other hand, if both the springs are connected at the midpoint of the rod, as shown in Fig. 2 and the rod is made to oscillate by a small angular displacement, then the frequency of oscillation is f_2. Ignoring gravity and assuming motion only in the plane of the diagram, the value of $\frac{f_1}{f_2}$ is:

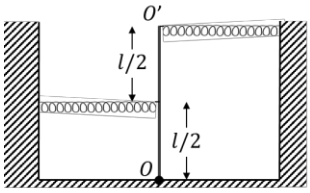


Fig. 1

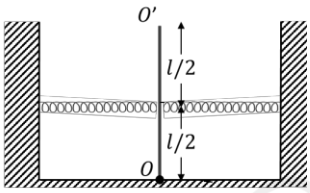


Fig. 2

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

Q.4

Consider a star of mass m_2 kg revolving in a circular orbit around another star of mass m_1 kg with $m_1 \gg m_2$. The heavier star slowly acquires mass from the lighter star at a constant rate of γ kg/s. In this transfer process, there is no other loss of mass. If the separation between the centers of the stars is r, then its relative rate of change $\frac{1}{r}\frac{dr}{dt}$ (in s^{-1}) is given by:

(A)	$-\frac{3\gamma}{2m_2}$	(B)	$-\frac{2\gamma}{m_2}$	(C)	$-\frac{2\gamma}{m_1}$	(D)	$-\frac{3\gamma}{2m_1}$

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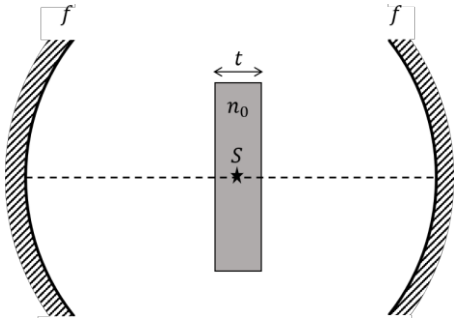
- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then
  choosing ONLY (A), (B) and (D) will get $+4$ marks;
  choosing ONLY (A) and (B) will get $+2$ marks;
  choosing ONLY (A) and (D) will get $+2$ marks;
  choosing ONLY (B) and (D) will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

Q.5 A positive point charge of 10^{-8} C is kept at a distance of 20 cm from the center of a neutral conducting sphere of radius 10 cm. The sphere is then grounded and the charge on the sphere is measured. The grounding is then removed and subsequently the point charge is moved by a distance of 10 cm further away from the center of the sphere along the radial direction. Taking $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ $\mathrm{Nm^2/C^2}$ (where ϵ_0 is the permittivity of free space), which of the following statements is/are correct:

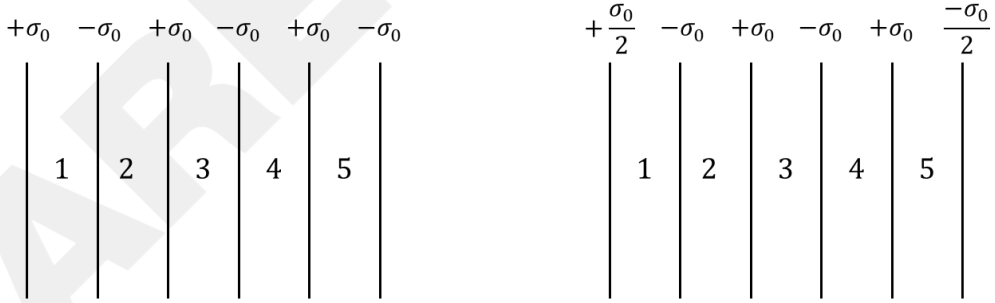
(A)	Before the grounding, the electrostatic potential of the sphere is 450 V.
(B)	Charge flowing from the sphere to the ground because of grounding is 5×10^{-9} C.
(C)	After the grounding is removed, the charge on the sphere is -5×10^{-9} C.
(D)	The final electrostatic potential of the sphere is 300 V.

Q.6 Two identical concave mirrors each of focal length f are facing each other as shown in the schematic diagram. The focal length f is much larger than the size of the mirrors. A glass slab of thickness t and refractive index n_0 is kept equidistant from the mirrors and perpendicular to their common principal axis. A monochromatic point light source S is embedded at the center of the slab on the principal axis, as shown in the schematic diagram. For the image to be formed on S itself, which of the following distances between the two mirrors is/are correct:



(A)	$4f + \left(1 - \frac{1}{n_0}\right)t$	(B)	$2f + \left(1 - \frac{1}{n_0}\right)t$
(C)	$4f + (n_0 - 1)t$	(D)	$2f + (n_0 - 1)t$

Q.7 Six infinitely large and thin non-conducting sheets are fixed in configurations I and II. As shown in the figure, the sheets carry uniform surface charge densities which are indicated in terms of σ_0. The separation between any two consecutive sheets is 1 μm. The various regions between the sheets are denoted as 1, 2, 3, 4 and 5. If $\sigma_0 = 9\ \mu$C/m^2, then which of the following statements is/are correct:
(Take permittivity of free space $\epsilon_0 = 9 \times 10^{-12}$ F/m)



(A)	In region 4 of the configuration I, the magnitude of the electric field is zero.
(B)	In region 3 of the configuration II, the magnitude of the electric field is $\frac{\sigma_0}{\epsilon_0}$.
(C)	Potential difference between the first and the last sheets of the configuration I is 5 V.
(D)	Potential difference between the first and the last sheets of the configuration II is zero.

Q.8 The efficiency of a Carnot engine operating with a hot reservoir kept at a temperature of 1000 K is 0.4. It extracts 150 J of heat per cycle from the hot reservoir. The work extracted from this engine is being fully used to run a heat pump which has a coefficient of performance 10. The hot reservoir of the heat pump is at a temperature of 300 K. Which of the following statements is/are correct:

(A)	Work extracted from the Carnot engine in one cycle is 60 J.
(B)	Temperature of the cold reservoir of the Carnot engine is 600 K.
(C)	Temperature of the cold reservoir of the heat pump is 270 K.
(D)	Heat supplied to the hot reservoir of the heat pump in one cycle is 540 J.

SECTION 3 (Maximum Marks: 32)

- This section contains **EIGHT (08)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- 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**:
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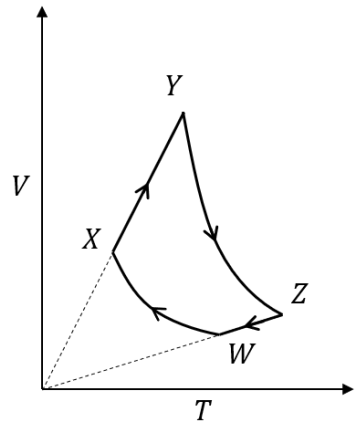
  Zero Marks : 0 In all other cases.

Q.9 A conducting solid sphere of radius R and mass M carries a charge Q. The sphere is rotating about an axis passing through its center with a uniform angular speed ω. The ratio of the magnitudes of the magnetic dipole moment to the angular momentum about the same axis is given as $\alpha \frac{Q}{2M}$. The value of α is ___

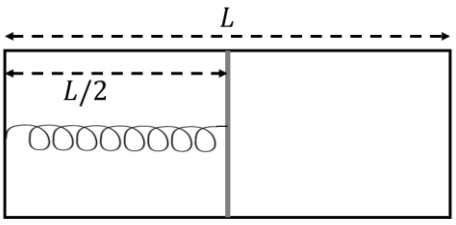
Q.10 A hydrogen atom, initially at rest in its ground state, absorbs a photon of frequency ν_1 and ejects the electron with a kinetic energy of 10 eV. The electron then combines with a positron at rest to form a positronium atom in its ground state and simultaneously emits a photon of frequency ν_2. The center of mass of the resulting positronium atom moves with a kinetic energy of 5 eV. It is given that positron has the same mass as that of electron and the positronium atom can be considered as a Bohr atom, in which the electron and the positron orbit around their center of mass. Considering no other energy loss during the whole process, the difference between the two photon energies (in eV) is ___

Q.11 An ideal monatomic gas of n moles is taken through a cycle $WXYZW$ consisting of consecutive adiabatic and isobaric quasi-static processes, as shown in the schematic V-T diagram. The volume of the gas at W, X and Y points are, $64\ \text{cm}^3$, $125\ \text{cm}^3$ and $250\ \text{cm}^3$, respectively. If the absolute temperature of the gas T_W at the point W is such that $nRT_W = 1$ J (R is the universal gas constant), then the amount of heat absorbed (in J) by the gas along the path XY is ___

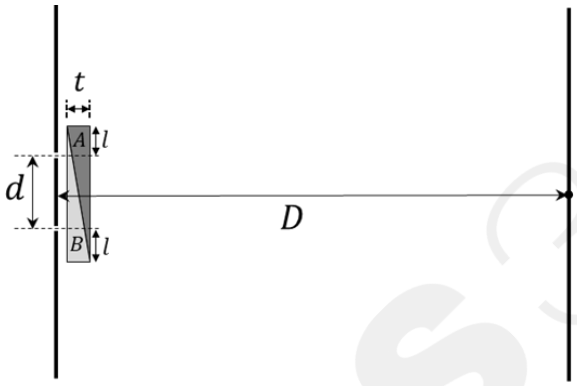


Q.12 A geostationary satellite above the equator is orbiting around the earth at a fixed distance r_1 from the center of the earth. A second satellite is orbiting in the equatorial plane in the opposite direction to the earth's rotation, at a distance r_2 from the center of the earth, such that $r_1 = 1.21\, r_2$. The time period of the second satellite as measured from the geostationary satellite is $\frac{24}{p}$ hours. The value of p is ___

Q.13 The left and right compartments of a thermally isolated container of length L are separated by a thermally conducting, movable piston of area A. The left and right compartments are filled with $\frac{3}{2}$ and 1 moles of an ideal gas, respectively. In the left compartment the piston is attached by a spring with spring constant k and natural length $\frac{2L}{5}$. In thermodynamic equilibrium, the piston is at a distance $\frac{L}{2}$ from the left and right edges of the container as shown in the figure. Under the above conditions, if the pressure in the right compartment is $P = \frac{kL}{A}\alpha$, then the value of α is ____

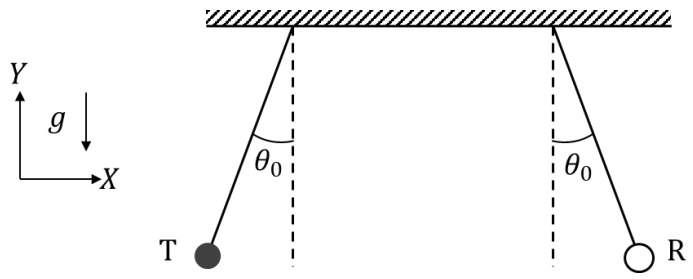


Q.14 In a Young's double slit experiment, a combination of two glass wedges A and B, having refractive indices 1.7 and 1.5, respectively, are placed in front of the slits, as shown in the figure. The separation between the slits is $d = 2$ mm and the shortest distance between the slits and the screen is $D = 2$ m. Thickness of the combination of the wedges is $t = 12$ μm. The value of l as shown in the figure is 1 mm. Neglect any refraction effect at the slanted interface of the wedges. Due to the combination of the wedges, the central maximum shifts (in mm) with respect to O by ____



Q.15 A projectile of mass 200 g is launched in a viscous medium at an angle 60° with the horizontal, with an initial velocity of 270 m/s. It experiences a viscous drag force $\vec{F} = -c\vec{v}$ where the drag coefficient $c = 0.1$ kg/s and $\vec{v}$ is the instantaneous velocity of the projectile. The projectile hits a vertical wall after 2 s. Taking $e = 2.7$, the horizontal distance of the wall from the point of projection (in m) is ____

Q.16 An audio transmitter (T) and a receiver (R) are hung vertically from two identical massless strings of length 8 m with their pivots well separated along the X axis. They are pulled from the equilibrium position in opposite directions along the X axis by a small angular amplitude $\theta_0 = \cos^{-1}(0.9)$ and released simultaneously. If the natural frequency of the transmitter is 660 Hz and the speed of sound in air is 330 m/s, the maximum variation in the frequency (in Hz) as measured by the receiver (Take the acceleration due to gravity $g = 10$ m/s^2) is ___



END OF THE QUESTION PAPER

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.

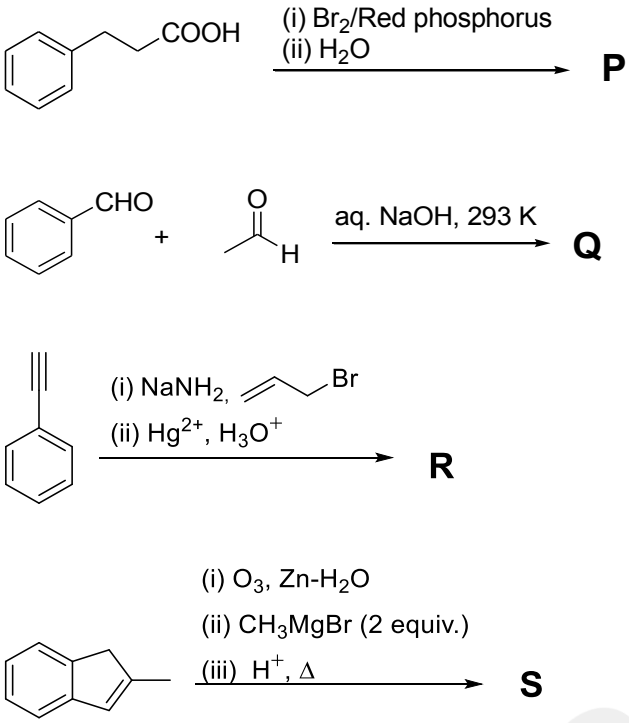
Q.1 During sodium nitroprusside test of sulphide ion in an aqueous solution, one of the ligands coordinated to the metal ion is converted to

(A)	NOS^-	(B)	SCN^-	(C)	SNO^-	(D)	NCS^-

Q.2 The complete hydrolysis of ICl, ClF_3 and BrF_5, respectively, gives

(A)	IO^-, ClO_2^- and BrO_3^-
(B)	IO_3^-, ClO_2^- and BrO_3^-
(C)	IO^-, ClO^- and BrO_2^-
(D)	IO_3^-, ClO_4^- and BrO_2^-

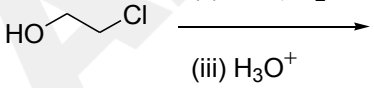
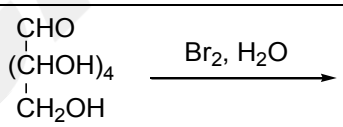
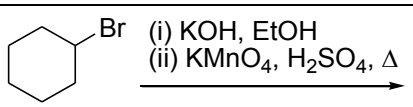
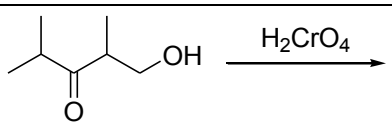
Q.3 Monocyclic compounds **P**, **Q**, **R** and **S** are the major products formed in the reaction sequences given below.



The product having the highest number of unsaturated carbon atom(s) is

(A)	**P**	(B)	**Q**
(C)	**R**	(D)	**S**

Q.4 The correct reaction/reaction sequence that would produce a dicarboxylic acid as the major product is

(A)	
(B)	
(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 : -2 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 mark;
  choosing ONLY (B) will get +1 mark;
  choosing ONLY (D) will get +1 mark;
  choosing no option (i.e. the question is unanswered) will get 0 marks; and
  choosing any other combination of options will get -2 marks.

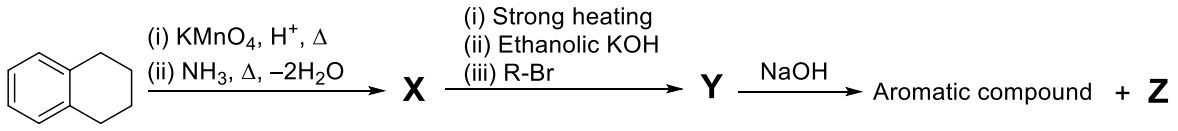
Q.5 The correct statement(s) about intermolecular forces is(are)

(A)	The potential energy between two point charges approaches zero more rapidly than the potential energy between a point dipole and a point charge as the distance between them approaches infinity.
(B)	The average potential energy of two rotating polar molecules that are separated by a distance r has $1/r^3$ dependence.
(C)	The dipole-induced dipole average interaction energy is independent of temperature.
(D)	Nonpolar molecules attract one another even though neither has a permanent dipole moment.

Q.6 The compound(s) with P–H bond(s) is(are)

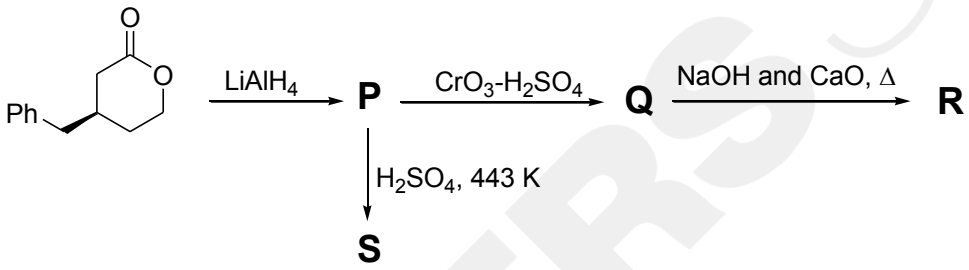
(A)	H_3PO_4
(B)	H_3PO_3
(C)	$H_4P_2O_7$
(D)	H_3PO_2

Q.7 For the reaction sequence given below, the correct statement(s) is(are)



(A)	Both **X** and **Y** are oxygen containing compounds.
(B)	**Y** on heating with $CHCl_3$/KOH forms isocyanide.
(C)	**Z** reacts with Hinsberg's reagent.
(D)	**Z** is an aromatic primary amine.

Q.8 For the reaction sequence given below, the correct statement(s) is(are)



(A)	**P** is optically active.
(B)	**S** gives Bayer's test.
(C)	**Q** gives effervescence with aq. $NaHCO_3$.
(D)	**R** is an alkyne.

SECTION 3 (Maximum Marks: 32)

- This section contains **EIGHT (08)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- 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.

Q.9 The density (in $\mathrm{g\,cm^{-3}}$) of the metal which forms a cubic close packed (ccp) lattice with an axial distance (edge length) equal to 400 pm is _____.

Use: Atomic mass of metal $= 105.6$ amu and Avogadro's constant $= 6 \times 10^{23}\ \mathrm{mol^{-1}}$

Q.10 The solubility of barium iodate in an aqueous solution prepared by mixing 200 mL of 0.010 M barium nitrate with 100 mL of 0.10 M sodium iodate is $\boldsymbol{X} \times 10^{-6}$ mol $\mathrm{dm^{-3}}$. The value of $\boldsymbol{X}$ is _____.

Use: Solubility product constant (K_{sp}) of barium iodate $= 1.58 \times 10^{-9}$

Q.11 Adsorption of phenol from its aqueous solution on to fly ash obeys Freundlich isotherm. At a given temperature, from 10 mg $\mathrm{g^{-1}}$ and 16 mg $\mathrm{g^{-1}}$ aqueous phenol solutions, the concentrations of adsorbed phenol are measured to be 4 mg $\mathrm{g^{-1}}$ and 10 mg $\mathrm{g^{-1}}$, respectively. At this temperature, the concentration (in mg $\mathrm{g^{-1}}$) of adsorbed phenol from 20 mg $\mathrm{g^{-1}}$ aqueous solution of phenol will be _____.

Use: $\log_{10} 2 = 0.3$

Q.12 Consider a reaction $A + R \longrightarrow Product$. The rate of this reaction is measured to be $k[A][R]$. At the start of the reaction, the concentration of R, $[R]_0$, is 10-times the concentration of A, $[A]_0$. The reaction can be considered to be a pseudo first order reaction with assumption that $k[R] = k'$ is constant. Due to this assumption, the relative error (in %) in the rate when this reaction is 40 % complete, is _____.
[k and k' represent corresponding rate constants]

Q.13 At 300 K, an ideal dilute solution of a macromolecule exerts osmotic pressure that is expressed in terms of the height (h) of the solution (density $= 1.00$ g cm^{-3}) where h is equal to 2.00 cm. If the concentration of the dilute solution of the macromolecule is 2.00 g dm^{-3}, the molar mass of the macromolecule is calculated to be $\boldsymbol{X} \times 10^4$ g mol^{-1}. The value of $\boldsymbol{X}$ is _____.

Use: Universal gas constant (R) $= 8.3$ J K^{-1} mol^{-1} and acceleration due to gravity (g) $= 10$ m s^{-2}

Q.14 An electrochemical cell is fueled by the combustion of butane at 1 bar and 298 K. Its cell potential is $\frac{\boldsymbol{X}}{F} \times 10^3$ volts, where F is the Faraday constant. The value of $\boldsymbol{X}$ is _____.

Use: Standard Gibbs energies of formation at 298 K are: $\Delta_f G^o_{CO_2} = -394$ kJ mol^{-1}; $\Delta_f G^o_{water} = -237$ kJ mol^{-1}; $\Delta_f G^o_{butane} = -18$ kJ mol^{-1}

Q.15 The sum of the spin only magnetic moment values (in B.M.) of $[Mn(Br)_6]^{3-}$ and $[Mn(CN)_6]^{3-}$ is _____.

Q.16 A linear octasaccharide (molar mass $= 1024$ g mol^{-1}) on complete hydrolysis produces three monosaccharides: ribose, 2-deoxyribose and glucose. The amount of 2-deoxyribose formed is 58.26 % (w/w) of the total amount of the monosaccharides produced in the hydrolyzed products. The number of ribose unit(s) present in one molecule of octasaccharide is _____.

Use: Molar mass (in g mol^{-1}): ribose $= 150$, 2-deoxyribose $= 134$, glucose $= 180$;
Atomic mass (in amu): H = 1, O = 16

END OF THE QUESTION PAPER