JEE (Advanced) 2026 — Paper 1

Complete Worked Solutions

Step-by-step explanations for JEE aspirants

Mathematics • Physics • Chemistry (48 questions)

How to use this booklet. Each question is given exactly as in the paper, followed by a figure where one helps, and then a worked solution explained step by step — the way it would be done on the board in class. The boxed line at the end of every solution is the final answer.

Paper pattern. 3 subjects $\times$ 16 questions = 48 questions. Each subject has 4 sections: **Section 1** (4 single-correct MCQs, $+3/-1$), **Section 2** (4 multiple-correct MCQs, $+4$ with partial marks, -1), **Section 3** (4 numerical questions, $+4/0$, answer rounded/truncated to 2 decimals), **Section 4** (4 Matching-List MCQs, $+4/-1$). Each subject is out of 60 marks; the full paper is 180.

About the figures. Figures in the Physics and Chemistry sections are the *actual figures from the original JEE (Advanced) 2026 Paper 1*, cropped directly from the question paper. The Mathematics section has a few *drawn* explanatory diagrams (the paper prints no figures there); these are clearly labelled and are standard textbook-style illustrations — a graph of a known function or a set of plotted points, exact by construction.

Important — four harder questions. Physics Q13 & Q15 and Chemistry Q4 & Q15 are intricate (tube-network path lengths, induced-current shapes, cyclobutane stereochemistry, ozonolysis-product matching). Our answers to these are given, but marked in red as the least certain — please cross-check them against the official key.

MATHEMATICS

Q.1 *Section 1 • Single correct • $+3/-1$*

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?

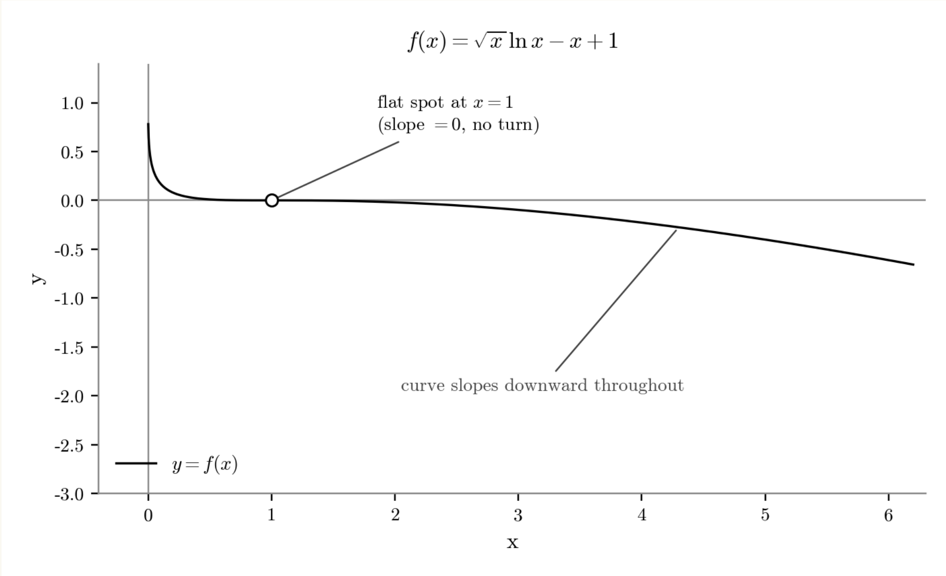
(A) The derivative of the function f is decreasing in the interval $(0, 1)$

(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 $(0, \infty)$

How to think about it: To find maxima/minima we look at $f'(x)$. A local max or min can only occur where f' *changes sign.* So we first find f', then check its sign.



Explanatory diagram (not in the original paper) — plotted from the exact equations to aid understanding.

The graph shows the key idea: f falls steadily everywhere. At $x = 1$ the slope momentarily becomes zero — the curve flattens for an instant — but it keeps going down. So $x = 1$ is a flat spot, not a peak or a valley.

Step 1: Differentiate.

Using the product rule on $\sqrt{x}\,\log_e x$:

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

Step 2: Make it simpler with a substitution.

Let $t = \sqrt{x}$ (so $t > 0$ and $\log_e x = 2\log_e t$). The top of the fraction becomes

$$2\log_e t + 2 - 2t = 2(\log_e t + 1 - t).$$

Step 3: Use a standard inequality.

There is a well-known result: $\log_e t \le t - 1$ for every $t > 0$, and they are equal only at $t = 1$. So $\log_e t + 1 - t \le 0$ always. That means the top of our fraction is never positive, so

$$f'(x) \le 0 \text{ for all } x > 0, \qquad f'(x) = 0 \text{ only at } x = 1.$$

Step 4: Conclude.

Since f' is never positive, it does *not* change sign at $x = 1$ — it just touches zero and stays negative on both sides. A point where f' does not change sign is neither a maximum nor a minimum. So (B) and (C) are wrong.

For (A): $f''(x) = -\dfrac{\log_e x}{4x^{3/2}}$. On $(0, 1)$, $\log_e x < 0$, so $f'' > 0$, which means f' is *increasing* there — not decreasing. So (A) is wrong, and (D) is correct.

▶ **Key point:** A stationary point ($f' = 0$) is a maximum or minimum *only if f' changes sign* there. If f' merely touches zero and keeps the same sign, the point is neither.

Final Answer: (D)

Q.2 *Section 1 • Single correct • +3/ − 1*

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

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

How to think about it: Find the three points one by one using "slope of tangent = $\frac{dy}{dx}$". Then, if the triangle has a right angle, the circle through the three corners has the hypotenuse as its diameter.

Step 1: Find P on $y = x^2$.

$\dfrac{dy}{dx} = 2x = 4 \Rightarrow x = 2$, so $y = 4$. Thus $P = (2, 4)$.

Step 2: Find Q on $x^2 + y^2 = 2$.

Differentiating: $2x + 2y\,y' = 0 \Rightarrow y' = -x/y = -1 \Rightarrow x = y$. Putting into the circle: $2x^2 = 2 \Rightarrow x = y = 1$. So $Q = (1, 1)$.

Step 3: Find R on $x^2 + 4y^2 = 8$.

Differentiating: $2x + 8y\,y' = 0 \Rightarrow y' = -x/(4y) = -\frac{1}{2} \Rightarrow x = 2y$. Putting in: $4y^2 + 4y^2 = 8 \Rightarrow y = 1,\ x = 2$. So $R = (2, 1)$.

Step 4: Spot the right angle.

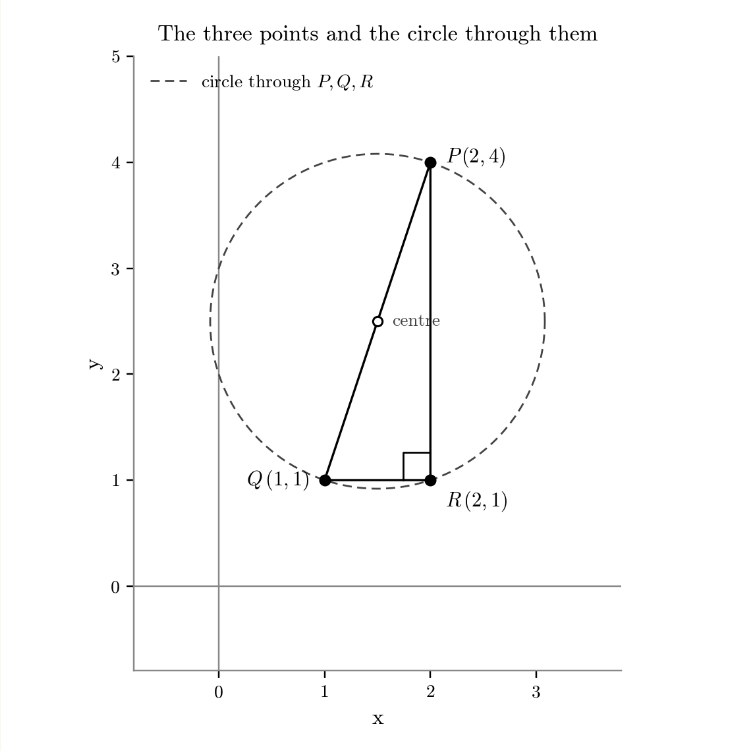
$P = (2, 4)$ and $R = (2, 1)$ have the same x, so PR is *vertical* (length 3). $Q = (1, 1)$ and $R = (2, 1)$ have the same y, so QR is *horizontal* (length 1). A vertical and a horizontal line meet at 90°, so the triangle has a right angle at R.

▶ **Key point:** For a right-angled triangle, the circle through all three vertices has the *hypotenuse as its diameter*. So the circumradius is just half the hypotenuse — no need for the general circumcircle formula.

Step 5: Use the right-angle property.

For a right triangle, the circumscribing circle has the hypotenuse PQ as diameter.

$$|PQ| = \sqrt{(2-1)^2 + (4-1)^2} = \sqrt{10}, \qquad \text{radius} = \tfrac{1}{2}\sqrt{10} = \sqrt{5/2}.$$



Explanatory diagram (not in the original paper) — plotted from the exact equations to aid understanding.

The diagram makes it clear: the triangle PQR has a right angle at R, so PQ is the hypotenuse and also the diameter of the circle through all three points. Half of $|PQ|$ is the radius.

Final Answer: (C)

Q.3 *Section 1 • Single correct • +3/ − 1*

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) $\begin{bmatrix}1&1&1\\-1&1&2\\0&2&3\end{bmatrix}$

How to think about it: Elementary row operations never change whether a matrix is invertible. The identity matrix is invertible, so any matrix obtained from it must also be invertible — that is, its determinant must NOT be zero. So we just check which option has a non-zero determinant.

Check each determinant.

(A) Every row is the same, so $\det = 0$ — rejected.
(B) $\det = 1(3-8) - 1(2-4) + 1(4-3) = -5 + 2 + 1 = -2 \neq 0$ — this works.
(C) $\det = 1(24-20) - 1(16-8) + 1(10-6) = 4 - 8 + 4 = 0$ — rejected.
(D) $\det = 1(3-4) - 1(-3-0) + 1(-2-0) = -1 + 3 - 2 = 0$ — rejected.
Only (B) is invertible.

Final Answer: (B)

Q.4 *Section 1 • Single correct • +3/ − 1*

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

$$\cot^{-1}\big(\cot(-11)\big) + 10\sin\Big(2\cos^{-1}\tfrac{1}{\sqrt{2}}\Big) + 10\sin\big(2\tan^{-1}2\big)$$

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

How to think about it: Each inverse-trig function has a fixed "principal range". The trick for the first term is to add a whole multiple of π to bring the angle inside that range, because cot repeats every π.

Term 1: $\cot^{-1}(\cot(-11))$.

The principal range of $\cot^{-1}$ is $(0, \pi)$. Since cot has period π, we add multiples of π to -11 until we land inside $(0, \pi)$. Adding 4π: $-11 + 4\pi \approx 1.566$, which lies in $(0, \pi)$. So this term $= 4\pi - 11$.

Term 2: $10\sin\big(2\cos^{-1}\frac{1}{\sqrt{2}}\big)$.

$\cos^{-1}\frac{1}{\sqrt{2}} = \frac{\pi}{4}$, so $2 \times \frac{\pi}{4} = \frac{\pi}{2}$, and $\sin\frac{\pi}{2} = 1$. This term $= 10$.

Term 3: $10\sin(2\tan^{-1}2)$.

If $\tan\theta = 2$, then $\sin 2\theta = \dfrac{2\tan\theta}{1+\tan^2\theta} = \dfrac{4}{5}$. This term $= 10 \times \frac{4}{5} = 8$.

Add them up.

$(4\pi - 11) + 10 + 8 = 4\pi + 7$.

Final Answer: (C)

Q.5 *Section 2 • One or more correct • +4 (partial marks), −1*

Box I contains 6 red and 9 green balls; Box II contains 8 red and 12 green balls. All balls are mixed together and one ball is chosen at random. Let E_1, E_2 be the events that the ball came from Box I, Box II respectively; let F_1, F_2 be the events that the ball is red, green respectively. Which statements are TRUE?
(A) E_1 and F_1 are independent
(B) E_2 and F_2 are dependent
(C) $P(F_1 \mid E_1) = P(F_1 \mid E_2)$
(D) $P(F_1 \mid E_1) > P(F_2 \mid E_2)$

How to think about it: There are $15+20 = 35$ balls in all, every ball equally likely. "Independent" means $P(E \cap F) = P(E) \times P(F)$. "Conditional probability" $P(F \mid E)$ means: given the ball is from that box, what fraction is red/green.

Set up the basic numbers.

Total $= 35$ balls: 14 red, 21 green. $P(E_1) = \frac{15}{35} = \frac{3}{7}$, $P(F_1) = \frac{14}{35} = \frac{2}{5}$.

(A) Check independence of E_1, F_1.

$P(E_1 \cap F_1) = \dfrac{6}{35}$ (red balls from Box I). Also $P(E_1)P(F_1) = \frac{3}{7} \times \frac{2}{5} = \frac{6}{35}$. They match $\Rightarrow$ independent. **TRUE.**

(B) Check E_2, F_2.

$P(E_2 \cap F_2) = \dfrac{12}{35}$; $P(E_2)P(F_2) = \frac{4}{7} \times \frac{3}{5} = \frac{12}{35}$. They match $\Rightarrow$ independent, not dependent. **FALSE.**

(C) Compare the conditional probabilities.

$P(F_1 \mid E_1) = \dfrac{6}{15} = \frac{2}{5}$ and $P(F_1 \mid E_2) = \dfrac{8}{20} = \frac{2}{5}$. Equal. **TRUE.**

(D) Compare again.

$P(F_1 \mid E_1) = 0.4$; $P(F_2 \mid E_2) = \dfrac{12}{20} = 0.6$. Since 0.4 is not greater than 0.6. **FALSE.**

Final Answer: (A), (C)

Q.6 *Section 2 • One or more correct • +4 (partial marks), −1*

Let P be the plane containing the line $\dfrac{x-1}{2} = \dfrac{y-3}{3} = \dfrac{z+2}{1}$ and perpendicular to the plane $x+2y+3z = 4$. Let P_1 pass through $(4, 2, 2)$ and be parallel to P. Which statements are TRUE?
(A) The equation of P is $7x - 5y + z = -10$
(B) The distance between P and P_1 is 30
(C) The distance of P from the origin is $2\sqrt{3}$
(D) The acute angle between P and the plane $2x + 2y + z = 3$ is $\cos^{-1}\left(\frac{1}{3\sqrt{3}}\right)$

How to think about it: The normal of plane P must be perpendicular to two things: the direction of the line lying in it, and the normal of the plane it is perpendicular to. "Perpendicular to both" means we take a cross product.

Step 1: Find the normal of P.

Line direction $\mathbf{d} = (2, 3, 1)$; given plane's normal $\mathbf{n_1} = (1, 2, 3)$.

$$\mathbf{n} = \mathbf{d} \times \mathbf{n_1} = (3 \cdot 3 - 1 \cdot 2,\ 1 \cdot 1 - 2 \cdot 3,\ 2 \cdot 2 - 3 \cdot 1) = (7, -5, 1).$$

Step 2: Write the equation of P.

P passes through the point $(1, 3, -2)$ on the line: $7(x-1)-5(y-3)+1(z+2) = 0$, i.e. $7x-5y+z = -10$. **(A) TRUE.**

Step 3: Plane P_1 and the distance.

P_1 is parallel, through $(4, 2, 2)$: $7(4) - 5(2) + 2 = 20$, so $P_1 :\ 7x - 5y + z = 20$.

$$\text{distance} = \frac{|20 - (-10)|}{\sqrt{7^2 + 5^2 + 1^2}} = \frac{30}{\sqrt{75}} = \frac{30}{5\sqrt{3}} = 2\sqrt{3}.$$

This is $2\sqrt{3}$, not 30. **(B) FALSE.**

Step 4: Distance of P from the origin.

$\dfrac{|-10|}{\sqrt{75}} = \dfrac{10}{5\sqrt{3}} = \dfrac{2}{\sqrt{3}} \approx 1.15$, which is not $2\sqrt{3} \approx 3.46$. **(C) FALSE.**

Step 5: Angle between the two planes.

Angle between planes = angle between normals $(7, -5, 1)$ and $(2, 2, 1)$:

$$\cos\theta = \frac{|7\cdot 2 + (-5)\cdot 2 + 1\cdot 1|}{\sqrt{75}\cdot\sqrt{9}} = \frac{5}{15\sqrt{3}} = \frac{1}{3\sqrt{3}}.$$

(D) TRUE.

Final Answer: (A), (D)

Q.7 *Section 2 • One or more correct • +4 (partial marks), −1*

Let $f : \mathbb{R} \to \mathbb{R}$ be an arbitrary function and $g : \mathbb{R} \to \mathbb{R}$ defined by $g(x) = x\,f(x)$ for all x. Which statements are TRUE?
(A) 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

How to think about it: The word "arbitrary" is a hint: f could behave badly. To prove a statement false, we only need one counterexample.

(A) Try a badly-behaved f.

Take $f(x) = 1/x^2$ for $x \neq 0$. Then $g(x) = x \cdot \frac{1}{x^2} = \frac{1}{x}$, which blows up as $x \to 0$. So g need not be continuous. **FALSE.**

(B) Use the definition of derivative.

$g'(0) = \lim_{h\to 0} \dfrac{g(h) - g(0)}{h} = \lim_{h\to 0} \dfrac{h\,f(h)}{h} = \lim_{h\to 0} f(h)$. If f is continuous at 0, this limit equals $f(0)$, so $g'(0)$ exists. **TRUE.**

(C) Try a counterexample.

Let $f(x) = 0$ for $x \neq 0$ but $f(0) = 5$. Then $g(x) = x\,f(x) = 0$ everywhere, so g is differentiable. But $\lim_{x\to 0} f(x) = 0 \neq 5 = f(0)$, so f is *not* continuous at 0. **FALSE.**

(D) From the same Step (B) idea.

If g is differentiable at 0, then $g'(0) = \lim_{h\to 0} f(h)$ — so that limit definitely exists. **TRUE.**

Final Answer: (B), (D)

Q.8 *Section 2 • One or more correct • +4 (partial marks), −1*

Consider the matrix $M = \begin{bmatrix} 2 & -1 \\ 1 & 0 \end{bmatrix}$. Let p, q, r, s, a, b, c, d be integers with $M^{26} = \begin{bmatrix} p & q \\ r & s \end{bmatrix}$ and $\sum_{k=1}^{26} M^k = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$. Which statements are TRUE?

(A) There exists a 2×2 invertible matrix N with $MN = N\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$
(B) The value of a is 378
(C) For any integers m, n, there exist unique integers x, y with $px + qy = m,\ rx + sy = n$
(D) For each $t > 0$, the system $(a+t)x + by = 1,\ cx + (d+t)y = -1$ has a unique solution

How to think about it: Powers of a 2×2 matrix are easy when $M - I$ "squares to zero". Then $M^n = I + n(M - I)$, a neat shortcut.

Step 1: Find the pattern of M^n.

The characteristic equation is $\det(M - \lambda I) = (\lambda - 1)^2 = 0$, so the only eigenvalue is 1 (repeated). Let $N_0 = M - I = \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix}$. Check: $N_0^2 = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$. Since $N_0^2 = 0$,

$$M^n = (I + N_0)^n = I + nN_0 = \begin{bmatrix} 1+n & -n \\ n & 1-n \end{bmatrix}.$$

► **Key point:** When $M - I$ squares to zero (a "nilpotent" matrix), the binomial expansion of $(I + N_0)^n$ stops after two terms: $M^n = I + nN_0$. This turns any power of M into a one-line formula.

Step 2: Compute the two required matrices.

$M^{26} = \begin{bmatrix} 27 & -26 \\ 26 & -25 \end{bmatrix}$. $\sum_{k=1}^{26} M^k = 26I + \left(\sum_{k=1}^{26} k\right) N_0 = 26I + 351N_0 = \begin{bmatrix} 377 & -351 \\ 351 & -325 \end{bmatrix}$, so $a = 377$.

(A) Jordan form.

M has eigenvalue 1 appearing twice but only one independent eigenvector, so its Jordan form is exactly $\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ — such an N exists. **TRUE.**

(B)

$a = 377$, not 378. **FALSE.**

(C) Unique integer solutions.

This holds when M^{26} maps integer pairs onto integer pairs one-to-one, which needs $\det M^{26} = \pm 1$. Here $\det M^{26} = (\det M)^{26} = 1^{26} = 1$. **TRUE.**

(D) Unique solution for all $t > 0$.

The determinant of the system is $(a + t)(d + t) - bc = t^2 + 52t + 676 = (t + 26)^2$, which is positive for every $t > 0$. A non-zero determinant means a unique solution. **TRUE.**

Final Answer: (A), (C), (D)

Q.9 *Section 3 • Numerical answer • +4/0*

Let $S = \{1, 2, 3, \ldots, 10\}$. Consider the set X of all equivalence relations R on the set S such that R has exactly 42 elements (ordered pairs). Then the number of elements in X is ___________.

How to think about it: An equivalence relation is the same as splitting the set into groups (a "partition"). If the group sizes are $n_1, n_2, \ldots$, the number of ordered pairs in the relation is $n_1^2 + n_2^2 + \cdots$. So we need group sizes adding to 10 with squares adding to 42.

Step 1: Find which group sizes work.

We need $\sum n_i = 10$ and $\sum n_i^2 = 42$. Testing partitions of 10: only two work — $\{6, 2, 1, 1\}$ (since $36 + 4 + 1 + 1 = 42$) and $\{5, 4, 1\}$ (since $25 + 16 + 1 = 42$).

Step 2: Count how many ways to make each partition with labelled elements.

For $\{5, 4, 1\}$: choose 5 elements, then 4 of the remaining 5, the last is fixed:

$$\binom{10}{5}\binom{5}{4}\binom{1}{1} = 252 \times 5 \times 1 = 1260.$$

For $\{6, 2, 1, 1\}$: choose 6, then 2 of remaining 4; the two single groups are identical so divide by 2!:

$$\frac{\binom{10}{6}\binom{4}{2}}{2!} = \frac{210 \times 6}{2} = 1260.$$

Step 3: Add.

$1260 + 1260 = 2520.$

Final Answer: 2520

Q.10 *Section 3 • Numerical answer • +4/0*

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

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

where $[\,\cdot\,]$ is the greatest integer function. Let α be the number of points where f is NOT continuous and β the number of points where f is NOT differentiable. Find $\alpha + \beta$.

How to think about it: Split f into two parts: a smooth-looking part $h(x) = (|x| + |x-1|)\sin x$ and a step part $[x \sin x]$. Modulus signs create "corners"; the greatest-integer function creates "jumps".

Step 1: Examine $h(x)$.

$|x|$ has a corner at $x = 0$, $|x-1|$ at $x = 1$. *At* $x = 0$: since $\sin 0 = 0$, the corner is "smoothed out" — checking slopes, $h'(0^-) = h'(0^+) = 1$, so h *is* differentiable at 0. *At* $x = 1$: $\sin 1 \neq 0$, slopes differ ($h'(1^-) = \cos 1$, $h'(1^+) = 2\sin 1 + \cos 1$), so h is *not* differentiable at $x = 1$. h is continuous everywhere.

Step 2: Examine $[x \sin x]$.

Let $g(x) = x \sin x$. It is an even function, rising from 0 to about $\pi/2 \approx 1.571$. So g takes the integer value 1 at two points $x = \pm c$ ($c \approx 1.114$). At those points $[x \sin x]$ *jumps* — so it is discontinuous (and hence non-differentiable) at $x = \pm c$ only.

Step 3: Count.

Discontinuities of f: only at $\pm c$, so $\alpha = 2$. Non-differentiable points of f: $x = 1$ (from h) and $x = \pm c$ (from the jumps), so $\beta = 3$.

$$\alpha + \beta = 2 + 3 = 5.$$

Final Answer: 5

Q.11 *Section 3 • Numerical answer • +4/0*

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 ____________.

How to think about it: If person i gets r_i red pens, the blue pens are forced: $b_i = 6 - r_i$. So we only have to count ways to hand out the red pens.

Step 1: Reduce the problem.

Once the reds are fixed, blues are automatic. We need $r_1 + r_2 + r_3 + r_4 = 10$ with each r_i between 0 and 6.

Step 2: Count without the upper limit.

Number of non-negative solutions of $r_1 + \cdots + r_4 = 10$ is $\binom{10+3}{3} = \binom{13}{3} = 286$.

Step 3: Remove cases that break $r_i \le 6$.

If some $r_i \ge 7$, write $r_i' = r_i - 7$; the equation becomes a sum $= 3$, giving $\binom{6}{3} = 20$ solutions. There are 4 persons, so subtract $4 \times 20 = 80$. Two persons cannot both exceed 6 (that needs at least 14).

$$286 - 80 = 206.$$

Final Answer: 206

Q.12 *Section 3* • *Numerical answer* • +4/0

Let
$$\alpha = \left(1 - 2\cos\tfrac{\pi}{11}\right)\left(1 - 2\cos\tfrac{3\pi}{11}\right)\left(1 - 2\cos\tfrac{9\pi}{11}\right)\left(1 - 2\cos\tfrac{27\pi}{11}\right)\left(1 - 2\cos\tfrac{81\pi}{11}\right).$$
Then the value of $5 - \alpha^2$ is ___________.

How to think about it: Cosine repeats every 2π, so first bring the large angles into a standard range. Then the five angles turn out to be a nice family, and the product can be evaluated using roots of $z^{11} + 1 = 0$.

Step 1: Reduce the angles.

$\dfrac{27\pi}{11} \equiv \dfrac{5\pi}{11}$ and $\dfrac{81\pi}{11} \equiv \dfrac{15\pi}{11}$, with $\cos\frac{15\pi}{11} = \cos\frac{7\pi}{11}$. So the angles are $\dfrac{k\pi}{11}$ for $k = 1, 3, 5, 7, 9$ — the odd multiples.

Step 2: Evaluate the product.

Using the factorisation $z^{11} + 1 = (z+1)\prod_k \left(z^2 - 2\cos\frac{k\pi}{11}\, z + 1\right)$ and substituting the special value $z = e^{i\pi/3}$ (where each quadratic factor becomes $z\,(1 - 2\cos\theta)$), the product simplifies to $\alpha = 1$. A quick numerical multiplication of the five brackets also gives ≈ 1.0003, confirming $\alpha = 1$.

Step 3: Final value.

$5 - \alpha^2 = 5 - 1 = 4.$

Final Answer: 4

Q.13 *Section 4* • *Matching List* • +4/ − 1

Match List-I with List-II, then choose the correct option.

List-I	List-II
(P) If α, β are distinct roots of $x^2+x+1=0$, 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, β are distinct roots of $x^2+x+1=0$, 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, δ are distinct roots of $x^2-x+1=0$, the value of $\frac{1}{(\gamma-1)^{2026}}+\frac{1}{(\delta-1)^{2026}}$ is	(3) $x^2+x-1=0$
(S) If p, r are distinct roots of $x^2+x-1=0$, 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

How to think about it: The roots of $x^2+x+1=0$ are the cube roots of unity ω, ω^2 (with $\omega^3=1$ and $1+\omega+\omega^2=0$). Big exponents are tamed by reducing them "mod 3".

(P) Exponent 2026.

Here $\alpha+1=-\omega^2$ and $\beta+1=-\omega$. Since $2026 \equiv 1 \pmod 3$, the two new roots simplify to ω and ω^2 — which satisfy $x^2+x+1=0$. **P→1.**

(Q) Exponent 2027.

Same idea with $2027 \equiv 2 \pmod 3$: the two roots come out as $-\omega$ and $-\omega^2$, whose sum is 1 and product is 1, giving $x^2-x+1=0$. **Q→2.**

(R)

Roots of $x^2-x+1=0$ give $\gamma-1=\omega,\ \delta-1=\omega^2$. Then $\frac{1}{\omega^{2026}}+\frac{1}{\omega^{4052}}=\omega^2+\omega=-1$. **R→4.**

(S)

With $u=p+1,\ v=r+1$: $u+v=1,\ uv=-1$. Then $\frac{1}{u^3}+\frac{1}{v^3}=\frac{(u+v)^3-3uv(u+v)}{(uv)^3}=\frac{1+3}{-1}=-4$. **S→5.**

Final Answer: (C) P→1, Q→2, R→4, S→5

Q.14 *Section 4 • Matching List • +4/−1*

Match List-I (the number of elements in each set) with List-II, then choose the correct option.

List-I	List-II
(P) $\{x \in [-\pi, \pi] : \sin^6 x + \cos^4 x = 1\}$	(1) is 1
(Q) $\{x \in [-\frac{\pi}{2}, \frac{\pi}{2}] : \sin^2 x + \cos^6 x = 1\}$	(2) is 2
(R) $\{x \in [-\pi, \pi] : \cos^2 \frac{x}{2} - \sin^2 x = \frac{1}{2}\}$	(3) is 3
(S) $\{x \in [-2\pi, 2\pi] : 6\sin^2 \frac{x}{2} - \cos 3x = 3\}$	(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

How to think about it: Replace $\sin^2 x$ or $\cos^2 x$ by a single letter, turn each equation into a polynomial, factor it, then count how many angles in the given interval fit.

(P)

With $s = \sin^2 x$: $\sin^6 x + \cos^4 x = 1$ becomes $s^3 + (1-s)^2 = 1 \Rightarrow s(s+2)(s-1) = 0$, so $s = 0$ or 1. This gives $x = -\pi, -\frac{\pi}{2}, 0, \frac{\pi}{2}, \pi$ — **5 solutions, P→5.**

(Q)

With $c = \cos^2 x$: $(1-c) + c^3 = 1 \Rightarrow c(c-1)(c+1) = 0$, so $c = 0$ or 1, giving $x = -\frac{\pi}{2}, 0, \frac{\pi}{2}$ — **3 solutions, Q→3.**

(R)

Using $\cos^2 \frac{x}{2} = \frac{1+\cos x}{2}$, the equation becomes $2t^2 + t - 2 = 0$ with $t = \cos x$; the valid root $t = \frac{-1+\sqrt{17}}{4} \approx 0.78$ gives **2 solutions, R→2.**

(S)

Using $\sin^2 \frac{x}{2} = \frac{1-\cos x}{2}$ and the triple-angle formula, it reduces to $4\cos^3 x = 0 \Rightarrow \cos x = 0$, giving $x = \pm\frac{\pi}{2}, \pm\frac{3\pi}{2}$ — **4 solutions, S→4.**

Final Answer: (B) P→5, Q→3, R→2, S→4

Q.15 *Section 4 • Matching List •* $+4/-1$

For real $\alpha, \beta, \gamma, \delta, \mu$, let $M = \begin{bmatrix} \alpha & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{3}} & \beta & \frac{1}{\sqrt{3}} \\ \gamma & \delta & \mu \end{bmatrix}$ with $MM^T = I$. Let $\vec{u} = \alpha\hat{\imath} + \frac{1}{\sqrt{3}}\hat{\jmath} + \gamma\hat{k}$, $\vec{v} = \frac{1}{\sqrt{2}}\hat{\imath} + \beta\hat{\jmath} + \delta\hat{k}$, $\vec{w} = -\frac{1}{\sqrt{2}}\hat{\imath} + \frac{1}{\sqrt{3}}\hat{\jmath} + \mu\hat{k}$. Match List-I with List-II, then choose the correct option.

List-I	List-II
(P) The value of $\gamma^2 + \delta^2$ is	(1) 0
(Q) If $x\vec{u} + y\vec{v} + z\vec{w} = \hat{\jmath}$ for some reals x, y, z, then the value of x is	(2) 1
(R) The value of $\lvert\vec{u} \cdot (\vec{v} \times \vec{w})\rvert$ is	(3) $\frac{1}{\sqrt{2}}$
(S) The value of $\lvert\vec{u} \times (\vec{v} \times \vec{w})\rvert$ 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

How to think about it: $MM^T = I$ means the *rows* of M are unit vectors and mutually perpendicular. For a square matrix this also forces $M^T M = I$, so the *columns* are an orthonormal set too — and the columns are exactly $\vec{u}, \vec{v}, \vec{w}$.

Step 1: Find the unknowns.

Row 1 has length 1: $\alpha^2 + \frac{1}{2} + \frac{1}{2} = 1 \Rightarrow \alpha = 0$. Row 2: $\frac{1}{3} + \beta^2 + \frac{1}{3} = 1 \Rightarrow \beta = \frac{1}{\sqrt{3}}$. Orthogonality conditions give $\delta = \mu$, $\gamma = -2\delta$ and $6\delta^2 = 1$.

(P)

$\gamma^2 + \delta^2 = 4\delta^2 + \delta^2 = 5\delta^2 = 5 \cdot \frac{1}{6} = \frac{5}{6}$. **P→5.**

(Q)

Since $\vec{u}, \vec{v}, \vec{w}$ are orthonormal, dotting $x\vec{u} + y\vec{v} + z\vec{w} = \hat{\jmath}$ with $\vec{u}$ gives $x = \hat{\jmath} \cdot \vec{u} =$ ($\hat{\jmath}$-component of $\vec{u}$) $= \frac{1}{\sqrt{3}}$. **Q→4.**

(R)

$\vec{u} \cdot (\vec{v} \times \vec{w})$ is the determinant of M; an orthogonal matrix has det $= \pm 1$, so the magnitude is 1. **R→2.**

(S)

$\vec{v} \times \vec{w} = \pm\vec{u}$ (perpendicular unit vector), so $\vec{u} \times (\pm\vec{u}) = \vec{0}$. **S→1.**

Final Answer: (A) P→5, Q→4, R→2, S→1

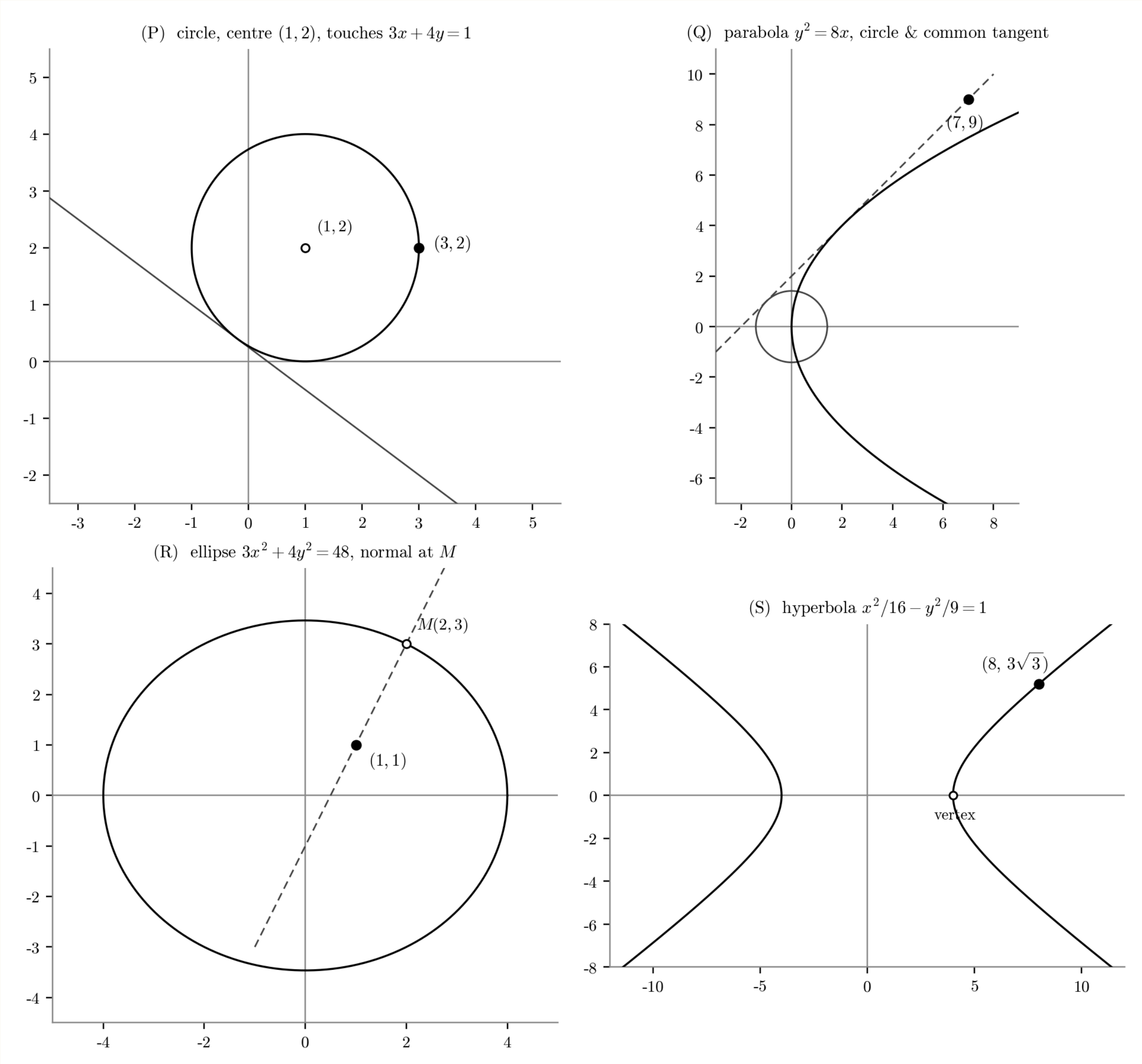
Q.16 *Section 4 • Matching List • +4/ − 1*

Match List-I with List-II, then choose the correct option.

List-I	List-II
(P) The circle with centre $(1, 2)$ touching the line $3x + 4y = 1$ passes through	(1) the point $(1, 1)$
(Q) The common tangent with positive slope to $x^2 + y^2 = 2$ and $y^2 = 8x$ passes through	(2) the point $(7, 9)$
(R) The normal to the ellipse $3x^2 + 4y^2 = 48$ at the first-quadrant end of the latus rectum passes through	(3) the point $(3, 2)$
(S) The hyperbola with centre at the origin, a focus at $(5, 0)$ and directrix $5x + 16 = 0$ 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

How to think about it: Find each curve, then simply test which listed point satisfies its equation.



Explanatory diagram (not in the original paper) — plotted from the exact equations to aid understanding.

Four separate curves, one per part. Each panel shows the curve and the listed point that lies on it (for R, the point lies on the normal line drawn at M). The matching is found by checking which point fits each equation.

(P)

Radius = distance from $(1, 2)$ to the line $= \dfrac{|3+8-1|}{5} = 2$. Circle: $(x-1)^2 + (y-2)^2 = 4$. The point $(3, 2)$ fits. **P→3.**

(Q)

A tangent to $y^2 = 8x$ is $y = mx + \frac{2}{m}$. Demanding it also touches $x^2 + y^2 = 2$ gives $m^4 + m^2 - 2 = 0 \Rightarrow m = 1$. Line $y = x + 2$ passes through $(7, 9)$. **Q→2.**

(R)

Ellipse $\frac{x^2}{16} + \frac{y^2}{12} = 1$: latus-rectum end $M = (2, 3)$; normal there is $y = 2x - 1$, which passes through $(1, 1)$. **R→1.**

(S)

For the hyperbola, $c = 5$ and directrix $x = -\frac{16}{5}$ gives $\frac{a^2}{c} = \frac{16}{5} \Rightarrow a^2 = 16,\ b^2 = 9$. So $\frac{x^2}{16} - \frac{y^2}{9} = 1$, which passes through $(8, 3\sqrt{3})$. **S→5.**

Final Answer: (B) P→3, Q→2, R→1, S→5

PHYSICS

Q.1 *Section 1 • Single correct • +3/ − 1*

Consider a large disk of radius R and two smaller disks, each of radius $r = R/50$, lying on its circumference. The smaller disks are initially in contact with each other, with an angular separation $\Delta\theta$ between their centres. They 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 $\sin(\Delta\theta) = \Delta\theta$; ignore gravity.]
(A) $\tau = 51\left(2\pi - \frac{4}{51}\right)/\omega$ (B) $\tau = 51\left(2\pi - \frac{2}{51}\right)/3\omega$
(C) $\tau = 51\left(2\pi - \frac{4}{51}\right)/3\omega$ (D) $\tau = 51\left(2\pi - \frac{2}{51}\right)/\omega$

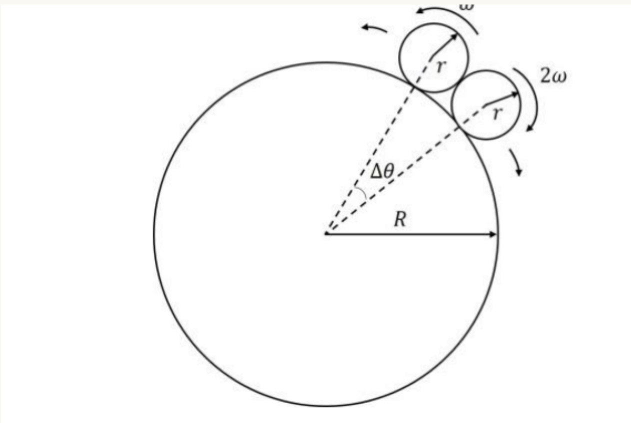


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: There are two different "spins" to keep separate: how fast each small disk turns on its own axis, and how fast its centre travels around the big disk. Rolling without slipping links the two.

Step 1: Link spinning to going around.

When a small disk rolls on the big one, its centre moves on a circle of radius $R + r$. The rolling condition gives:

$$(\text{rate of going around}) = (\text{spin rate}) \times \frac{r}{R+r} = \frac{\text{spin rate}}{51},$$

since $\dfrac{R+r}{r} = \dfrac{50r+r}{r} = 51.$

Step 2: Relative speed of the two disks.

Their "going around" rates are $\omega/51$ and $2\omega/51$, in *opposite* directions. So they approach each other at the combined rate $\dfrac{\omega}{51} + \dfrac{2\omega}{51} = \dfrac{3\omega}{51}.$

Step 3: Initial gap.

The two centres are a chord $2r$ apart. For a small angle, chord $= (R + r)\,\Delta\theta$, so $\Delta\theta = \dfrac{2r}{R+r} = \dfrac{2}{51}.$

Step 4: When do they meet again?

They part on one side and must close the rest of the circle. The angle to cover is $2\pi - 2\Delta\theta = 2\pi - \dfrac{4}{51}.$
Time = angle ÷ relative rate:

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

Final Answer: (C)

Q.2 *Section 1 • Single correct • +3/ − 1*

A circuit has a capacitor C and a coil with N turns per unit length, cross-section S, length d (with $d^2 \gg S$), self-inductance L. A smaller coil of length $d/2$, cross-section $S/2$, $2N$ turns per unit length sits completely inside the larger coil; its two ends are joined by an insulated wire. Neglecting edge effects and all resistances, the resonant frequency is:

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

How to think about it: A shorted coil placed inside another changes the effective inductance the circuit "feels". The key formula: with coupling factor k, the effective inductance becomes $L(1 - k^2)$.

Step 1: Self-inductance of the small coil.

For a solenoid, $L \propto (\text{turns per length})^2 \times (\text{area}) \times (\text{length})$.

$$L' = \mu_0 (2N)^2 \left(\frac{S}{2}\right)\left(\frac{d}{2}\right) = \mu_0 N^2 S d = L.$$

So the small coil also has inductance L.

Step 2: Mutual inductance and coupling.

Working out the linked flux gives $M = \dfrac{L}{2}$, so the coupling factor is

$$k = \frac{M}{\sqrt{L \cdot L'}} = \frac{L/2}{L} = \frac{1}{2}.$$

Step 3: Effective inductance.

The inner coil is shorted with no resistance, so it reduces the inductance to

$$L_{\text{eff}} = L(1 - k^2) = L\left(1 - \tfrac{1}{4}\right) = \tfrac{3}{4}L.$$

▶ **Key point:** A shorted, perfectly-conducting coil coupled to the main coil does not just sit there — it lowers the effective inductance to $L(1 - k^2)$. Forgetting this factor is the most common mistake in this problem.

Step 4: Resonant frequency.

$$\omega = \frac{1}{\sqrt{L_{\text{eff}}\, C}} = \frac{1}{\sqrt{\frac{3}{4}LC}} = \frac{2}{\sqrt{3LC}}.$$

Final Answer: (C)

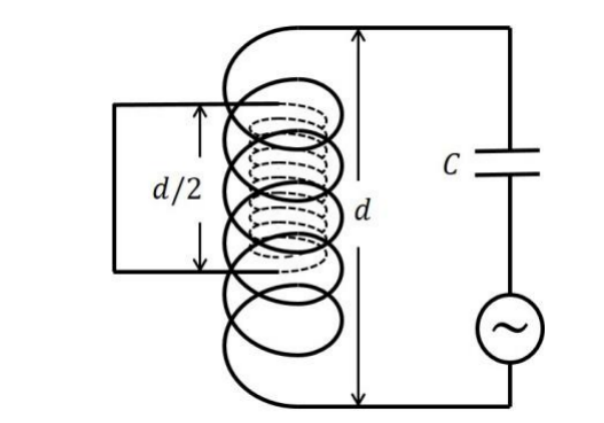


Figure from the original JEE (Advanced) 2026 Paper 1.

Q.3 *Section 1 • Single correct • +3/ − 1*

A solid cylinder of radius R rolls without slipping with centre-of-mass speed $v_0 = \sqrt{gR/3}$ on a horizontal surface having a vertical edge. At the moment the cylinder loses contact with the surface due to rotation around the corner, the speed of its centre of mass is:
(A) 0 (B) $\sqrt{5gR/7}$ (C) $\sqrt{gR/15}$ (D) $\sqrt{3gR/7}$

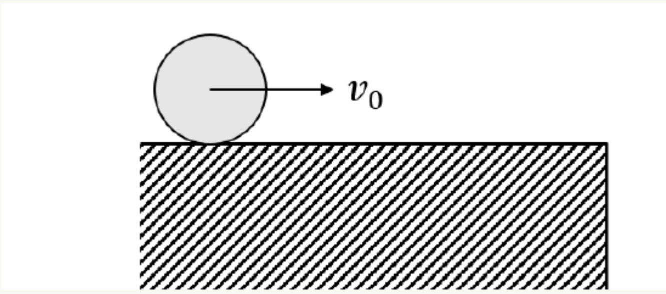


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Three ideas in order: (1) at the corner, angular momentum about the corner is conserved; (2) as the cylinder swings around the corner, use energy conservation; (3) it leaves the surface when the normal force becomes zero.

Step 1: Moment of inertia about the corner.

$I_{\text{corner}} = I_{\text{cm}} + mR^2 = \frac{1}{2}mR^2 + mR^2 = \frac{3}{2}mR^2$.

Step 2: Angular momentum at the corner.

Just before: $L = I_{\text{cm}}\omega_0 + mv_0R = \frac{3}{2}mv_0R$. Just after: $L = I_{\text{corner}}\omega_1$. Equating gives $\omega_1 = v_0/R$ — the rolling motion carries over smoothly with no sudden change.

Step 3: Energy conservation while swinging.

As the cylinder turns through angle θ, the centre drops by $R(1 - \cos\theta)$:

$$\omega^2 = \omega_1^2 + \frac{4g}{3R}(1 - \cos\theta), \qquad \omega_1^2 = \frac{v_0^2}{R^2} = \frac{g}{3R}.$$

Step 4: Condition for losing contact.

The centre moves on a circle of radius R; the normal force is $N = mg\cos\theta - m\omega^2 R$. It leaves the surface when $N = 0$, i.e. $\omega^2 = \dfrac{g\cos\theta}{R}$. Setting the two expressions for ω^2 equal:

$$\frac{g\cos\theta}{R} = \frac{g}{3R} + \frac{4g}{3R}(1-\cos\theta) \;\Rightarrow\; \cos\theta = \frac{5}{7}.$$

Step 5: Speed at that moment.

$\omega^2 = \dfrac{g}{R}\cdot\dfrac{5}{7} = \dfrac{5g}{7R}$, so $v_{\text{cm}} = \omega R = \sqrt{\dfrac{5gR}{7}}$.

Final Answer: (B)

Q.4 *Section 1 • Single correct • +3/ − 1*

A double convex lens made of glass of refractive index 1.5, with radii of curvature 20 cm each, is immersed in a liquid of refractive index n_L. The correct plot of the power (in dioptres) versus n_L is: [options (A)–(D) are four graphs]

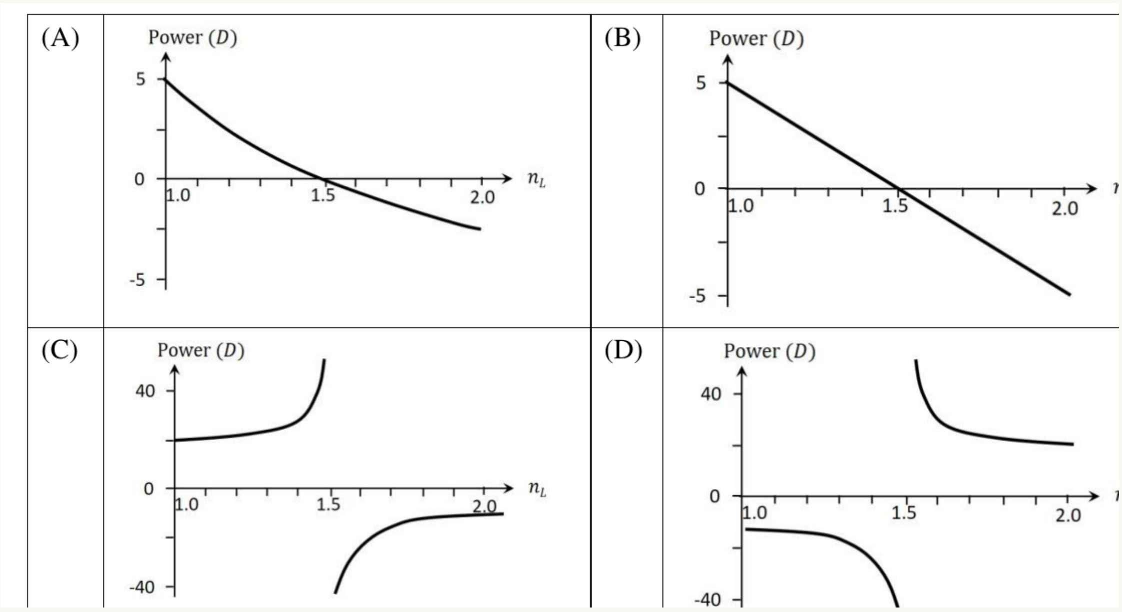


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Use the lens-maker's formula for a lens sitting in a medium: the "n" in it becomes the *ratio* of glass index to liquid index.

Step 1: The curvature part.

For a double convex lens, $\dfrac{1}{R_1} - \dfrac{1}{R_2} = \dfrac{1}{0.2} - \dfrac{1}{(-0.2)} = 10\ \text{m}^{-1}$.

Step 2: Write the power.

$$P = \left(\frac{n_{\text{glass}}}{n_L} - 1\right)\times 10 = \left(\frac{1.5}{n_L} - 1\right)\times 10 = \frac{15}{n_L} - 10.$$

Step 3: Read off the shape.

This is a *decreasing, curved* ($1/n_L$-type) graph: $P = 5$ D at $n_L = 1$, $P = 0$ at $n_L = 1.5$ (glass and liquid match, lens does nothing), $P = -2.5$ D at $n_L = 2$. The graph with this exact behaviour — modest values, crossing zero at 1.5, curved — is option (A).

Final Answer: (A)

Q.5 *Section 2 • One or more correct • +4 (partial marks), −1*

For a hydrogen atom let v_k, r_k, K_k be the velocity, orbital radius and kinetic energy of the electron in the kth orbit. The electron makes a transition from the nth orbit, emitting a Lyman-series line. Which statements are correct? (h = Planck's constant, ϵ_0 = permittivity of free space)

(A) $|\Delta K| = \dfrac{h}{4\pi}\left|\dfrac{nv_n}{r_n} - \dfrac{v_1}{r_1}\right|$

(B) $|\Delta\lambda| = \dfrac{e^2}{4\epsilon_0}\left|\dfrac{1}{K_n} - \dfrac{1}{K_1}\right|$

(C) frequency $= \dfrac{e^2}{8\pi\epsilon_0 h}\left(\dfrac{1}{r_1} - \dfrac{1}{r_n}\right)$

(D) $|\Delta E_{\text{total}}| = \dfrac{h}{2\pi}\left|\dfrac{v_1}{r_1} - \dfrac{nv_n}{r_n}\right|$

How to think about it: Use the Bohr-model facts: $K_k \propto 1/k^2$, $r_k \propto k^2$, de Broglie wavelength $\lambda_k \propto k$, and total energy $= -$ (kinetic energy).

(A)

From angular momentum quantisation $mv_k r_k = \frac{kh}{2\pi}$, one gets $K_k = \frac{1}{2}mv_k^2 = \dfrac{h}{4\pi}\dfrac{kv_k}{r_k}$. So $|\Delta K| = \dfrac{h}{4\pi}\left|\dfrac{nv_n}{r_n} - \dfrac{v_1}{r_1}\right|$ — this matches. **TRUE.**

(B)

$\lambda_k = 2\pi r_k/k \propto k$, so $|\Delta\lambda| \propto (n-1)$. But the proposed formula has $\left|\frac{1}{K_n} - \frac{1}{K_1}\right| \propto (n^2 - 1)$. They differ by a factor $(n+1)$. **FALSE.**

(C)

The photon energy $h\nu = |\Delta E| = \dfrac{e^2}{8\pi\epsilon_0}\left(\dfrac{1}{r_1} - \dfrac{1}{r_n}\right)$, so dividing by h gives exactly (C). **TRUE.**

(D)

Total energy $= -K$, so $|\Delta E_{\text{total}}| = |\Delta K| = \dfrac{h}{4\pi}|\cdots|$. The option has $\dfrac{h}{2\pi}$ — twice too big. **FALSE.**

Final Answer: (A), (C)

Q.6 *Section 2 • One or more correct • +4 (partial marks), −1*

A particle is thrown with speed v from point O at angle θ to the horizontal, and passes through point P at height 1 m and horizontal distance 5 m from O. With g the acceleration due to gravity:

(A) If $\theta = 45°$, then $v = \dfrac{5\sqrt{g}}{2}$ m/s

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

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

(D) If $\theta = \tan^{-1}(1/5)$, then $v = 125\sqrt{g}$ m/s

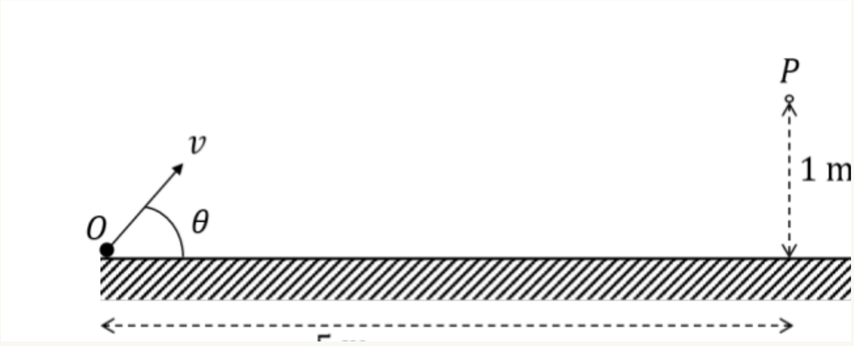


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Use the trajectory equation $y = x\tan\theta - \dfrac{gx^2}{2v^2\cos^2\theta}$ with the known point $P = (5, 1)$.

(A) $\theta = 45°$.

$1 = 5(1) - \dfrac{g(25)}{2v^2(1/2)} = 5 - \dfrac{25g}{v^2}$, so $\dfrac{25g}{v^2} = 4 \Rightarrow v^2 = \dfrac{25g}{4} \Rightarrow v = \dfrac{5\sqrt{g}}{2}$. **TRUE.**

(B)

Highest point is at $x = \dfrac{v^2\sin\theta\cos\theta}{g} = \dfrac{v^2}{2g} = \dfrac{25/4}{2} = 3.125$ m. Since $3.125 < 5$, the top is reached *before* P. **TRUE.**

(C) $\theta = 30°$.

The trajectory equation gives $v^2 \approx 8.83g$; then the top is at $x = \dfrac{v^2\sqrt{3}}{4g} \approx 3.8$ m < 5 m. So the top is reached *before* P, not after. **FALSE.**

(D) $\theta = \tan^{-1}(1/5)$.

Here $x\tan\theta = 5 \times \frac{1}{5} = 1$, which already equals P's height of 1 m. Any real gravity drop would pull y below 1, so no finite v can work. **FALSE.**

Final Answer: (A), (B)

Q.7 *Section 2 • One or more correct • +4 (partial marks), −1*

A quasi-static cycle of a monoatomic ideal gas has an isothermal process ab, then an isochoric process bc, then an adiabatic process ca. The volumes at a and b are V_1 and V_2. With efficiency $\eta = (Q_{in} - Q_{out})/Q_{in}$ and $\ln 2 \approx 0.7$:
(A) If $V_2/V_1 = 8$, heat released in bc is smaller than heat absorbed in ab
(B) For a fixed V_2/V_1, η is independent of the isothermal temperature
(C) If $V_2/V_1 = 8$, temperature at a is $4\times$ temperature at c
(D) If $V_2/V_1 = 8$, pressure at a is $4\times$ pressure at b

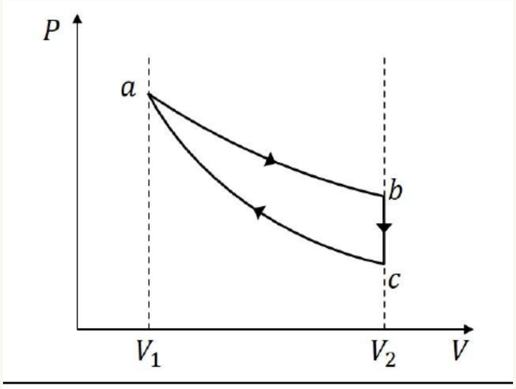


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: For a monoatomic gas $\gamma = 5/3$. The adiabatic step links the temperatures at c and a.

Step 1: Temperatures.

Adiabatic ca: $T_c V_2^{\gamma-1} = T_a V_1^{\gamma-1} \Rightarrow \dfrac{T_c}{T_a} = \left(\dfrac{V_1}{V_2}\right)^{2/3}$. For $V_2/V_1 = 8$: $\dfrac{T_c}{T_a} = (1/8)^{2/3} = \frac{1}{4}$, so $T_a = 4T_c$.

(A)

Heat absorbed in isothermal ab: $Q_{ab} = nRT_a \ln 8 = 3\ln 2\, nRT_a \approx 2.1\, nRT_a$. Heat released in isochoric bc: $|Q_{bc}| = C_v \Delta T = \frac{3}{2}R \cdot \frac{3}{4}T_a = 1.125\, nRT_a$. Since $1.125 < 2.1$. **TRUE.**

(B)

Both Q_{in} and Q_{out} are proportional to T_a, so when you take their ratio for η, the temperature cancels — η depends only on V_2/V_1. **TRUE.**

(C)

Shown above: $T_a = 4T_c$. **TRUE.**

(D)

For the isothermal step, $P_a V_1 = P_b V_2$, so $\dfrac{P_a}{P_b} = \dfrac{V_2}{V_1} = 8$, not 4. **FALSE.**

Final Answer: (A), (B), (C)

Q.8 *Section 2 • One or more correct • +4 (partial marks), −1*

The electric field of an EM wave in vacuum is $E_0 \sin(3y + 4z + \omega t)\,\hat{\imath}$. With $c = 3 \times 10^8$ m/s:
(A) The wave travels in the $-\frac{1}{5}(3\hat{\jmath} + 4\hat{k})$ direction
(B) The wave-vector magnitude is 0.5 m^{-1}
(C) $\omega = 1.5 \times 10^9$ rad/s
(D) $\mathbf{B} = \dfrac{E_0}{c}\sin(3y + 4z + \omega t)(4\hat{\jmath} - 3\hat{k})$

How to think about it: Read the wave-vector $\mathbf{k}$ straight from inside the sine. A "$+\omega t$" with "$+\mathbf{k}\cdot\mathbf{r}$" means the wave moves along $-\mathbf{k}$.

Find k.

$\mathbf{k} = (0, 3, 4)$, so $|\mathbf{k}| = \sqrt{0 + 9 + 16} = 5\ \text{m}^{-1}$.

(A)

Direction of travel is $-\hat{\mathbf{k}} = -\frac{1}{5}(3\hat{\jmath} + 4\hat{k})$. **TRUE.**

(B)

$|\mathbf{k}| = 5\ \text{m}^{-1}$, not 0.5. **FALSE.**

(C)

For an EM wave, $\omega = c|\mathbf{k}| = 3 \times 10^8 \times 5 = 1.5 \times 10^9$ rad/s. **TRUE.**

(D)

$\mathbf{B}$ must be along $\hat{\mathbf{k}}_{\text{travel}} \times \mathbf{E}$. Computing $-\frac{1}{5}(3\hat{\jmath} + 4\hat{k}) \times \hat{\imath} = \frac{1}{5}(3\hat{k} - 4\hat{\jmath})$. The option uses $(4\hat{\jmath} - 3\hat{k})$ — wrong sign — and is missing the 1/5 (so its magnitude is also wrong). **FALSE.**

Final Answer: (A), (C)

Q.9 *Section 3 • Numerical answer • +4/0*

A tank contains two immiscible liquids of densities 6ρ and 2ρ; the denser liquid fills up to height $L/2$ from the bottom. A thin rod of density ρ and length L is fully immersed and hinged at the bottom so it can swing freely. For small disturbances the time period is $\frac{2\pi}{n}\sqrt{\frac{L}{g}}$. Find n.

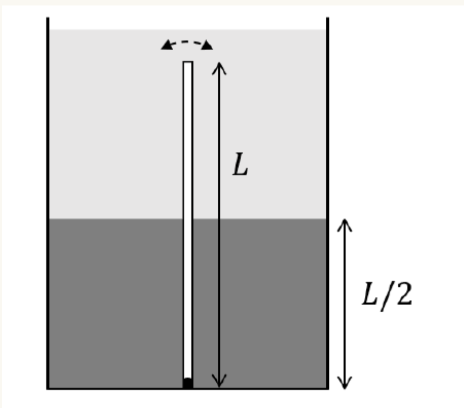


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: For small swings, find the "restoring torque per unit angle" (κ) and the moment of inertia (I). Then $\omega = \sqrt{\kappa/I}$, exactly like a pendulum.

Step 1: The forces and where they act.

Weight $W = \rho A L g$ at the centre ($L/2$ from hinge) — this tends to topple the rod. Buoyancy on the lower half (denser liquid): $6\rho \cdot A\frac{L}{2}\, g = 3\rho A L g$, acting at $L/4$. Buoyancy on the upper half: $2\rho \cdot A\frac{L}{2}\, g = \rho A L g$, acting at $3L/4$.

Step 2: Restoring-torque coefficient.

The two upward buoyant forces are restoring, the weight is upsetting:

$$\kappa = 3\rho A L g \cdot \tfrac{L}{4} + \rho A L g \cdot \tfrac{3L}{4} - \rho A L g \cdot \tfrac{L}{2} = \rho A L^2 g\Big(\tfrac{3}{4} + \tfrac{3}{4} - \tfrac{1}{2}\Big) = \rho A L^2 g.$$

Step 3: Moment of inertia about the hinge.

For a uniform rod about its end: $I = \frac{1}{3}(\rho AL)L^2 = \frac{1}{3}\rho AL^3$.

Step 4: Period.

$$\omega^2 = \frac{\kappa}{I} = \frac{\rho AL^2 g}{\frac{1}{3}\rho AL^3} = \frac{3g}{L}, \qquad T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{L}{3g}} = \frac{2\pi}{\sqrt{3}}\sqrt{\frac{L}{g}}.$$

Comparing with $\dfrac{2\pi}{n}\sqrt{\frac{L}{g}}$ gives $n = \sqrt{3}$.

Final Answer: $n = \sqrt{3} \approx 1.73$

Q.10 *Section 3 • Numerical answer • +4/0*

As shown in the figure below, five Carnot engines, each of efficiency η and the same number of cycles per unit time, operate between six reservoirs; the heat released by one engine is fully absorbed by the next. If Q_0 is the heat absorbed by the first engine and W the total work of all five engines, the net efficiency is $\eta_{\text{net}} = W/Q_0 = 211/243$. Find η.

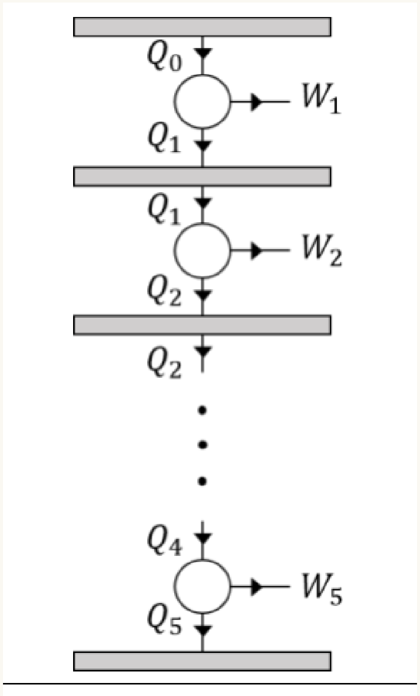


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Each engine passes on a fraction $(1-\eta)$ of the heat to the next. After five engines, the leftover heat is $(1-\eta)^5$ of Q_0.

Step 1: Net efficiency.

Total work $= Q_0 -$ (final leftover heat) $= Q_0\left[1-(1-\eta)^5\right]$, so $\eta_{\text{net}} = 1-(1-\eta)^5$.

Step 2: Solve.

$$1-(1-\eta)^5 = \frac{211}{243} \;\Rightarrow\; (1-\eta)^5 = \frac{32}{243} = \left(\frac{2}{3}\right)^5 \;\Rightarrow\; 1-\eta = \frac{2}{3}.$$

So $\eta = \dfrac{1}{3}$.

Final Answer: $\eta = \dfrac{1}{3} \approx 0.33$

Q.11 *Section 3 • Numerical answer • +4/0*

An insulated container has a thermally conducting but fixed partition P_1 (conductivity K, area A, width x) and a freely movable, insulated piston P_2. The partition divides the container into S_1 and S_2, each with one mole of a monoatomic gas; S_2 stays at atmospheric pressure. Initially the temperature difference is ΔT_0. The time for it to fall to $\Delta T_0/2$ is nxR/KA. Find n. [$\ln 2 \approx 0.7$]

How to think about it: S_1 has fixed volume, so it uses C_v. S_2 stays at constant pressure, so it uses C_p. Heat flows from hot to cold at a rate proportional to the temperature difference — this gives exponential decay.

Step 1: Rate equations.

$C_v \dfrac{dT_1}{dt} = -\dfrac{KA}{x}\Delta T$ and $C_p \dfrac{dT_2}{dt} = +\dfrac{KA}{x}\Delta T$, where $\Delta T = T_1 - T_2$.

Step 2: Equation for the difference.

$$\frac{d(\Delta T)}{dt} = -\frac{KA}{x}\left(\frac{1}{C_v} + \frac{1}{C_p}\right)\Delta T.$$

For a monoatomic gas $C_v = \frac{3}{2}R,\ C_p = \frac{5}{2}R$, so $\dfrac{1}{C_v} + \dfrac{1}{C_p} = \dfrac{2}{3R} + \dfrac{2}{5R} = \dfrac{16}{15R}$.

Step 3: Exponential decay and half-time.

The difference decays with time-constant $\tau = \dfrac{15R}{16}\dfrac{x}{KA}$. It halves after $t = \tau \ln 2$:

$$t = \frac{15\ln 2}{16} \cdot \frac{xR}{KA} \;\Rightarrow\; n = \frac{15\ln 2}{16} = \frac{15 \times 0.7}{16} \approx 0.66.$$

Final Answer: $n = \dfrac{15\ln 2}{16} \approx 0.66$

Q.12 *Section 3 • Numerical answer • +4/0*

A hollow right circular cone of base radius R and height h, tip at the origin, rotates about the Z-axis with angular velocity ω. It carries total charge Q spread uniformly on its curved surface. The magnetic field at $(0, 0, z)$ with $z \gg R, h$ is $\dfrac{n\mu_0}{4\pi}\dfrac{QR^2\omega}{z^3}$. Find n.

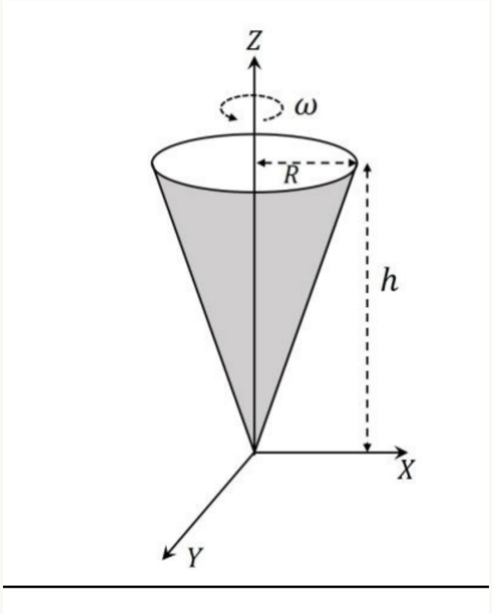


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Slice the cone into thin horizontal rings. A spinning charged ring is a tiny current loop; add up (integrate) the magnetic moments of all rings.

Step 1: A ring at height ζ.

Its radius is $\frac{R}{h}\zeta$. Working out the charge on a thin ring: $dq = \dfrac{2Q}{h^2}\zeta\, d\zeta$ (one can check $\int_0^h dq = Q$).

Step 2: Current and magnetic moment of the ring.

Spinning at ω: $dI = \dfrac{\omega}{2\pi}dq = \dfrac{Q\omega}{\pi h^2}\zeta\, d\zeta$. Magnetic moment = current × area:

$$dm = dI \cdot \pi\left(\tfrac{R}{h}\zeta\right)^2 = \frac{Q\omega R^2}{h^4}\zeta^3\, d\zeta.$$

Step 3: Total moment.

$$m = \int_0^h \frac{Q\omega R^2}{h^4}\zeta^3\, d\zeta = \frac{Q\omega R^2}{h^4}\cdot\frac{h^4}{4} = \frac{Q\omega R^2}{4}.$$

Step 4: Field on the axis.

A dipole gives $B = \dfrac{\mu_0}{4\pi}\dfrac{2m}{z^3} = \dfrac{\mu_0}{4\pi}\dfrac{QR^2\omega}{2z^3}$. Comparing with the given form, $n = \frac{1}{2}$.

Final Answer: $n = \dfrac{1}{2} = 0.5$

Q.13 *Section 4 • Matching List • +4/ − 1*

List-I shows four tube networks (straight and semicircular tubes), drawn in the figure below. A sound wave of wavelength $\lambda = 0.29$ m enters at S; a detector is at D. List-II gives the smallest length l for which D records maximum amplitude. Match them, then choose the correct option. [$\cos 15° = 0.97$]

List-I	List-II
(P) Tube network (P) in the figure below	(1) 1.32 m
(Q) Tube network (Q) in the figure below	(2) 1.19 m
(R) Tube network (R) in the figure below	(3) 0.51 m
(S) Tube network (S) in the figure below	(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

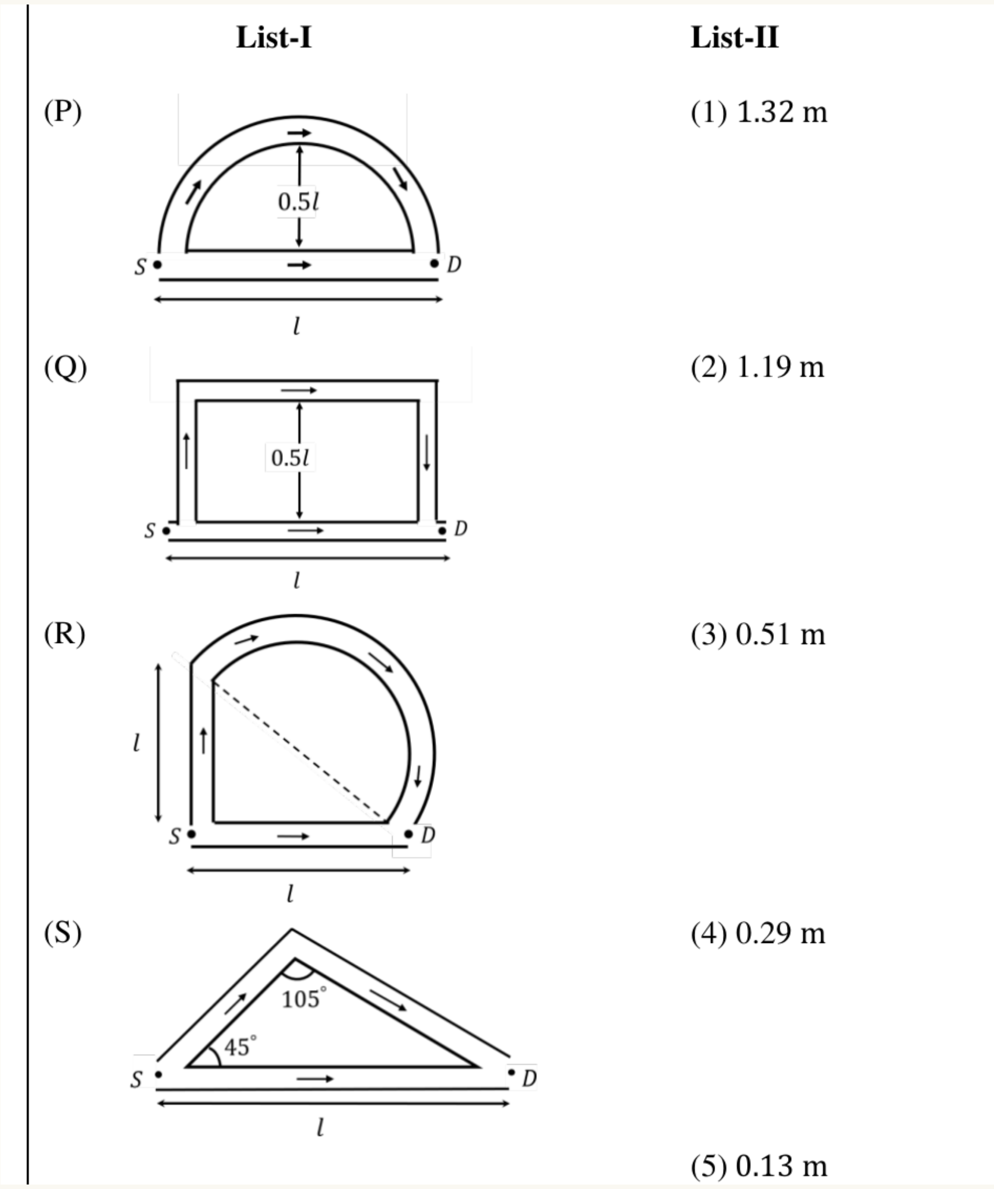


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: For the detector to hear a *maximum*, the two paths from S to D must differ by exactly one wavelength (the smallest non-zero case): path difference $= \lambda = 0.29$ m.

Method.

For each network, work out the two path lengths in terms of l, set their difference equal to λ, and solve for the smallest l. Doing this for each: (P) semicircular detour $\Rightarrow l = 0.51$ m $\rightarrow$(3); (Q) rectangular detour $\Rightarrow l = 0.29$ m $\rightarrow$(4); (R) L-path versus a semicircular arc on the diagonal $\Rightarrow l \approx 1.32$ m $\rightarrow$(1); (S) triangle with $45°/105°/30°$, using $\cos 15° = 0.97 \Rightarrow l \approx 1.19$ m $\rightarrow$(2).

[Please verify with the official answer key:] Even with the figure in front of us, this question is intricate — the path lengths depend on exactly how each tube segment is measured. The matching below corresponds to option (C); please confirm with the official key.

Final Answer: (C) P→3, Q→4, R→1, S→2

Q.14 *Section 4 • Matching List • +4/ − 1*

Match each optical effect in List-I with the physical phenomenon in List-II, then choose the correct option.

List-I	List-II
(P) Aurora Borealis (colourful sky in the polar region)	(1) Dispersion and reflection
(Q) Partially polarized sunlight	(2) Total internal reflection
(R) Rainbow	(3) Diffraction
(S) Dark and bright fringes	(4) Scattering of light by atmospheric molecules
	(5) Emission of radiation from O and N 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

Reasoning.

(P) The aurora is light *given off* by oxygen and nitrogen atoms after charged particles from the Sun excite them → (5).
(Q) Sunlight becomes partly polarized because air molecules *scatter* it → (4).
(R) A rainbow needs the splitting of colours (dispersion) plus reflection inside raindrops → (1).
(S) Dark and bright fringes are a *diffraction* pattern → (3).

Final Answer: (A) P→5, Q→4, R→1, S→3

Q.15 *Section 4 • Matching List • +4/ − 1*

List-I shows four conducting loops in the XY-plane, rotating about the Z-axis through O with time period T (clockwise). The region $x > 0$ has a uniform field B along $+z$. List-II shows the induced-current graphs $i(t)$. Match them.

(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

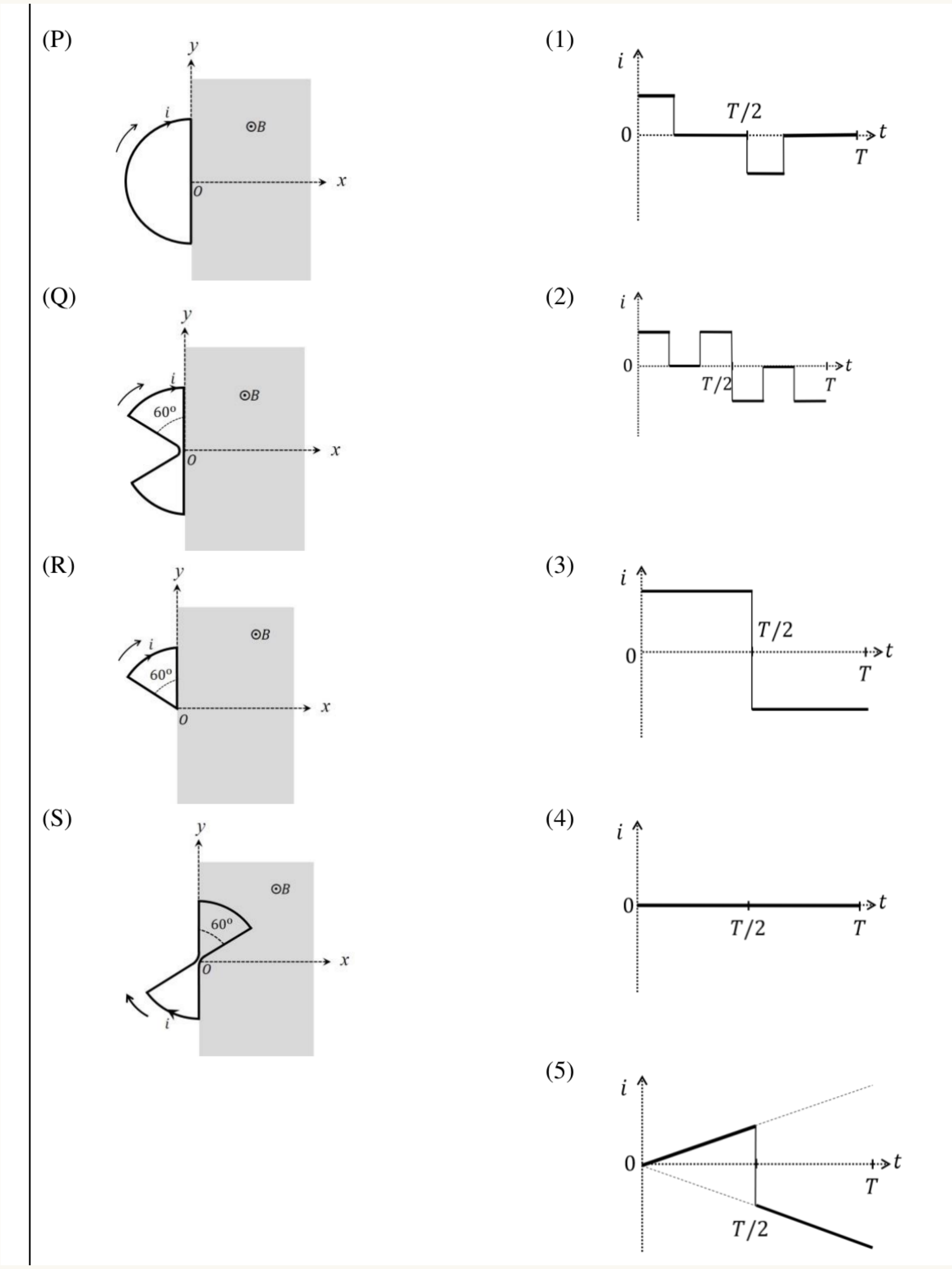


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: The induced current depends on *how fast* the part of the loop's area lying in the field region ($x > 0$) is changing as the loop turns.

Reasoning.

A straight radial edge sweeping past the boundary makes the area-in-field change at a steady rate, giving a flat (square-wave / step-shaped) current. Shapes whose area grows in a curved (quadratic) way give ramp-shaped currents. Matching each loop's geometry to its current shape gives the option below.

[Please verify with the official answer key:] The exact shapes and orientations of the four loops (a semicircle and three 60° sectors) are essential here and cannot be read with full confidence from the rendered figure. The matching below corresponds to option (C); this is the least certain Physics answer — please confirm with the official key.

[Please verify with the official answer key:] Working out the exact induced-current shape for each loop is intricate. The matching below corresponds to option (C); this is the least certain Physics answer — please confirm with the official key.

Final Answer: (C) P→3, Q→2, R→1, S→4

Q.16 *Section 4 • Matching List • +4/ − 1*

List-I shows four planar structures made of uniform rods, each of mass m and length l (drawn in the figure below). List-II gives the possible moment of inertia about an axis OCO' lying in the plane of the structure. Match them, then choose the correct option.

List-I	List-II
(P) Rod structure (P) in the figure below	(1) $\frac{5}{4}ml^2$
(Q) Rod structure (Q) in the figure below	(2) $\frac{1}{6}ml^2$
(R) Rod structure (R) in the figure below	(3) $\frac{1}{12}ml^2$
(S) Rod structure (S) in the figure below	(4) $\frac{2}{3}ml^2$
	(5) $\frac{1}{3}ml^2$

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

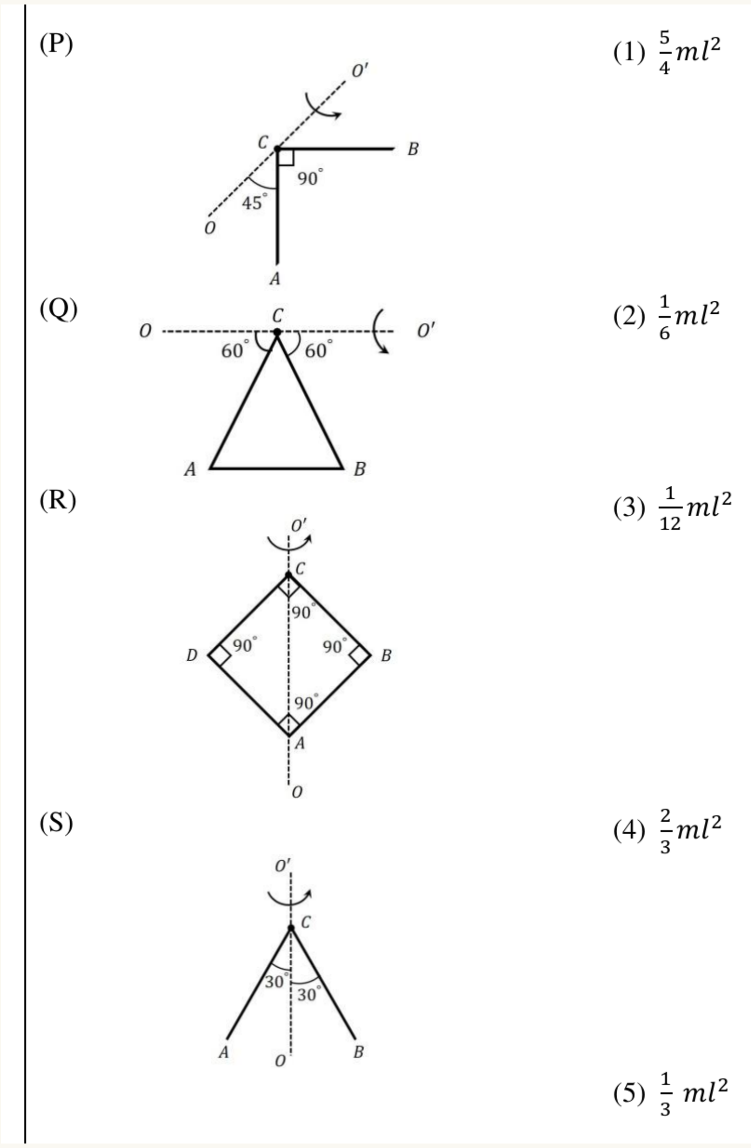


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Two simple rules for a rod: if a rod has one end on the axis and makes angle θ with it, its moment of inertia is $\frac{1}{3}ml^2\sin^2\theta$. If a rod is parallel to the axis at distance d, it is md^2.

(P)

Two rods, each with one end on the axis, each at 45°: $2 \times \frac{1}{3}ml^2\sin^2 45° = 2 \times \frac{1}{6}ml^2 = \frac{1}{3}ml^2 \rightarrow (5)$.

(Q)

Triangle: the two slant rods CA, CB at 60° give $2 \times \frac{1}{3}ml^2\sin^2 60° = \frac{1}{2}ml^2$; the base AB is parallel to the axis at distance $\frac{\sqrt{3}}{2}l$, giving $m\left(\frac{\sqrt{3}}{2}l\right)^2 = \frac{3}{4}ml^2$. Total $= \frac{1}{2}ml^2 + \frac{3}{4}ml^2 = \frac{5}{4}ml^2 \rightarrow (1)$.

(R)

Diamond, axis along the vertical diagonal: all four rods make 45° with the axis and have one end on it: $4 \times \frac{1}{3}ml^2\sin^2 45° = 4 \times \frac{1}{6}ml^2 = \frac{2}{3}ml^2 \rightarrow (4)$.

(S)

V-shape: two rods at 30° to the axis: $2 \times \frac{1}{3}ml^2\sin^2 30° = 2 \times \frac{1}{12}ml^2 = \frac{1}{6}ml^2 \rightarrow (2)$.

Final Answer: (A) P→5, Q→1, R→4, S→2

CHEMISTRY

Q.1 *Section 1 • Single correct • +3/ − 1*

An ideal gas (0.5 mol), initially at 2 bar, is compressed at constant temperature 600 K in two steps: first against a constant external pressure P bar ($2 < P < 8$), then against 8 bar. Each step stops when the gas pressure equals the external pressure. The total work done on the gas is W. Taking the gas constant as R, the minimum value of $|W|$ (in J) is
(A) $207R$ (B) $600R$ (C) $630R$ (D) $900R$

How to think about it: Work done on the gas in a step against constant external pressure is $-P_{\text{ext}}\Delta V$. Find W as a function of P, then minimise using calculus.

Step 1: Volumes at each stage.

$nRT = 0.5 \times R \times 600 = 300R$. Initial volume $V_i = \dfrac{300R}{2} = 150R$; after step 1, $V = \dfrac{300R}{P}$; after step 2, $V_f = \dfrac{300R}{8} = 37.5R$.

Step 2: Work in each step.

$W_1 = -P\left(\dfrac{300R}{P} - 150R\right) = -300R + 150RP.$
$W_2 = -8\left(37.5R - \dfrac{300R}{P}\right) = -300R + \dfrac{2400R}{P}.$

Step 3: Total and minimise.

$W(P) = 150RP + \dfrac{2400R}{P} - 600R$. Set $\dfrac{dW}{dP} = 150R - \dfrac{2400R}{P^2} = 0 \Rightarrow P^2 = 16 \Rightarrow P = 4$ bar.

Step 4: Value.

$W(4) = 600R + 600R - 600R = 600R.$

Final Answer: (B) $|W|_{\text{min}} = 600R$

Q.2 *Section 1 • Single correct • +3/ − 1*

For a reversible reaction $R \rightleftharpoons P$ at constant temperature, both forward and backward reactions are first order with rate constants k_f and k_b. At $t = 0$, $[R] = [R]_0$ and $[P] = 0$. If $k_b = 4k_f$, the correct graph of concentration ratios versus time is [options (A)–(D) are graphs].

How to think about it: At equilibrium the forward and backward rates are equal: $k_f[R]_{\text{eq}} = k_b[P]_{\text{eq}}$. Use this to find the final concentrations.

Step 1: Equilibrium ratio.

$k_b = 4k_f \Rightarrow k_f[R]_{\text{eq}} = 4k_f[P]_{\text{eq}} \Rightarrow [R]_{\text{eq}} = 4[P]_{\text{eq}}.$

Step 2: Use conservation of mass.

$[R]_{\text{eq}} + [P]_{\text{eq}} = [R]_0$, so $[P]_{\text{eq}} = \dfrac{[R]_0}{5}$ and $[R]_{\text{eq}} = \dfrac{4[R]_0}{5}$.

Step 3: Read the graph.

So $[R]/[R]_0$ falls from 1 and levels off at 0.8; $[P]/[R]_0$ rises from 0 and levels off at 0.2 — both approaching exponentially. The graph showing these final values is option (C).

Final Answer: (C)

Q.3 *Section 1 • Single correct • +3/ − 1*

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) $BF_3 < NH_4^+ < NH_3 < NF_3$

How to think about it: A perfectly symmetric molecule has zero dipole moment. For pyramidal molecules, check whether the lone-pair dipole *adds to* or *opposes* the bond dipoles.

Step 1: The symmetric ones.

BF_3 is trigonal planar and NH_4^+ is tetrahedral — both fully symmetric, so dipole moment = 0 for each.

Step 2: NF_3 versus NH_3.

In NF_3, the N–F bond dipoles point toward the F atoms; the lone-pair dipole on N points the *opposite* way, partly cancelling them — so NF_3 has only a *small* dipole.
In NH_3, the N–H bond dipoles point toward N, and the lone-pair dipole points the *same* way, so they add up — giving a *large* dipole.

Step 3: Order.

$BF_3 = NH_4^+$ (0) $< NF_3$ (small) $< NH_3$ (large).

Final Answer: (A)

Q.4 *Section 1 • Single correct • +3/ − 1*

Considering that $LiBH_4$ 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, S (formed from two methyl-substituted cyclobutane substrates, each bearing $-CO_2Et$ and $-CO_2H$, treated with $LiBH_4$ or with BH_3) is
(A) P & Q identical, R & S diastereomers (B) P & Q diastereomers, R & S identical
(C) P & Q diastereomers, R & S diastereomers (D) P & Q identical, R & S identical

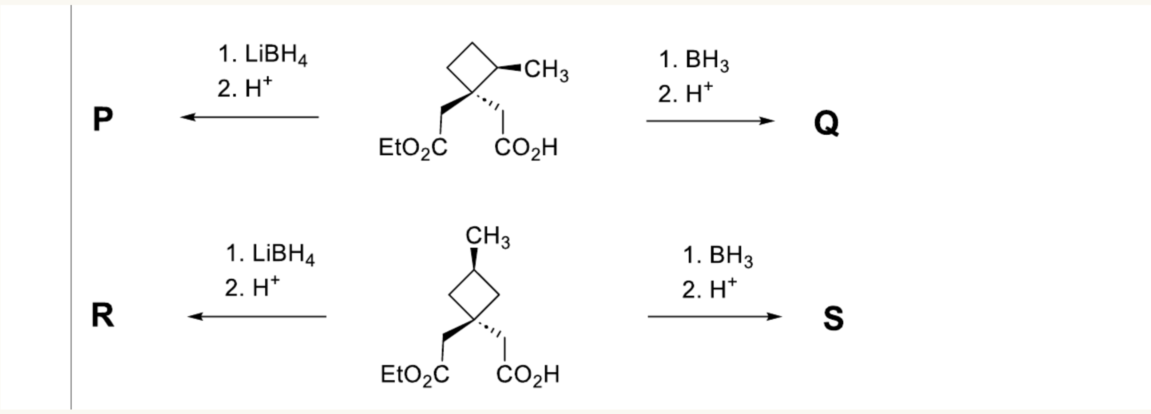


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: The two reagents are *selective*: $LiBH_4$ turns the ester into $-CH_2OH$ but leaves the acid; BH_3 turns the acid into $-CH_2OH$ but leaves the ester. Whether the products are the same compound or diastereomers depends on the *cis/trans* arrangement of the methyl group relative to the carboxyl groups in each starting material.

Reasoning.

Each substrate is a methyl-substituted cyclobutane carrying an ester and a carboxylic acid. Selectively reducing one group converts it to a hydroxymethyl group; the stereochemical relationship of the two products (P & Q from one substrate, R & S from the other) follows from how the methyl group is positioned with respect to the carboxyl groups.

[Please verify with the official answer key:] Deciding whether the products are identical or diastereomers means tracking the 3D configuration at each stereocentre through the reduction — intricate stereochemistry where a slip is easy. The tentative answer is option (A); please confirm with the official key.

Final Answer: (A) **tentative**

Q.5 *Section 2 • One or more correct • +4 (partial marks), −1*

$E_{2s}(\text{H}), E_{2p}(\text{H})$ are the 2s and 2p orbital energies of the hydrogen atom; $E_{2s}(\text{Li}), E_{2p}(\text{Li})$ those of lithium. Which statements are correct?
(A) $E_{2s}(\text{Li}) < E_{2p}(\text{Li})$ (B) $E_{2s}(\text{H}) = E_{2p}(\text{H})$
(C) $E_{2p}(\text{H}) < E_{2s}(\text{Li})$ (D) $E_{2s}(\text{H}) > E_{2s}(\text{Li})$

How to think about it: In a one-electron atom (hydrogen) the orbital energy depends only on n. In a many-electron atom (lithium) it depends on both n and l, because the 2s orbital “penetrates” closer to the nucleus.

(A)

In lithium, the 2s electron penetrates more and is held more tightly than 2p, so $E_{2s}(\text{Li}) < E_{2p}(\text{Li})$. **TRUE.**

(B)

In hydrogen, with only one electron, energy depends only on n; 2s and 2p have the same n, so $E_{2s}(\text{H}) = E_{2p}(\text{H})$. **TRUE.**

(C)

Roughly, $E_{2p}(\text{H}) \approx -3.4$ eV, while $E_{2s}(\text{Li}) \approx -5.4$ eV (lithium's larger nuclear charge holds it tighter). So $E_{2p}(\text{H})$ is *higher* (less negative) than $E_{2s}(\text{Li})$ — the stated “$<$” is wrong. **FALSE.**

(D)

$E_{2s}(\text{H}) \approx -3.4$ eV is higher (less negative) than $E_{2s}(\text{Li}) \approx -5.4$ eV, so $E_{2s}(\text{H}) > E_{2s}(\text{Li})$. **TRUE.**

Final Answer: (A), (B), (D)

Q.6 *Section 2 • One or more correct • +4 (partial marks), −1*

For the reactions: MnO_2+conc. HCl $\rightarrow$ $MnCl_2$+X (greenish-yellow gas) + H_2O; NH_3+X(excess) $\rightarrow$ Y + HCl; X + F_2(excess) $\xrightarrow{573K}$ Z. Which statements about X, Y, Z are correct?
(A) X is used for sterilizing 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

How to think about it: First identify X, Y, Z from the reactions, then judge each statement.

Identify X, Y, Z.

"Greenish-yellow gas" from MnO_2+conc. HCl is chlorine: $\mathbf{X} = \mathbf{Cl_2}$.
NH_3 with *excess* Cl_2 gives nitrogen trichloride: $\mathbf{Y} = \mathbf{NCl_3}$ (the reaction $NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$).
Cl_2 with excess F_2 at 573 K gives $\mathbf{Z} = \mathbf{ClF_3}$.

(A)

Cl_2 is indeed used to disinfect/sterilize drinking water. **TRUE.**

(B)

NCl_3 is pyramidal (the N atom has a lone pair, like NH_3) — not planar. **FALSE.**

(C)

ClF_3 is used to make UF_6, the compound used in ^{235}U enrichment. **TRUE.**

(D)

In NCl_3, the three electronegative Cl atoms pull electron density away from N, so its lone pair is *less* available — it is a *weaker* Lewis base than NH_3. **FALSE.**

Final Answer: (A), (C)

Q.7 *Section 2 • One or more correct • +4 (partial marks), −1*

Reaction of PtF_6 with O_2 gas gives an ionic compound X^+Y^-. Which statements are correct?
(A) The bond order of X^+ is 1.5 (B) The valence *d*-orbitals of the metal ion in X^+Y^- have 5 electrons
(C) PtF_6 acts as an oxidant in this reaction (D) PtF_6 acts as a fluorinating agent in this reaction

How to think about it: This is the famous reaction discovered by Bartlett: $PtF_6 + O_2 \rightarrow O_2^+[PtF_6]^-$. So $X^+ = O_2^+$ and $Y^- = [PtF_6]^-$.

(A)

O_2 has bond order 2. Removing one electron (from an anti-bonding orbital) to make O_2^+ *raises* the bond order to 2.5 — not 1.5. **FALSE.**

(B)

In $[PtF_6]^-$ the platinum is in the +5 state. Pt^{5+} has a $5d^5$ configuration — 5 *d*-electrons. **TRUE.**

(C)

PtF_6 pulls an electron off O_2 (oxidising it); PtF_6 itself is reduced, so it acts as the oxidant. **TRUE.**

(D)

No fluorine is transferred — all six F atoms stay on platinum in $[PtF_6]^-$. PtF_6 acts as an electron-acceptor, not a fluorinating agent. **FALSE.**

Final Answer: (B), (C)

Q.8 *Section 2 • One or more correct • +4 (partial marks), −1*

In a reaction sequence starting from a sodium carboxylate: (1) Kolbe's electrolysis, (2) V_2O_5, 500°C → Q; then Q + phthalic anhydride / anhyd. $AlCl_3$ → R; then R with (1) PCl_5, (2) H_2-Pd/$BaSO_4$ → S; then S + NH_2NH_2, heat → T. Which statements about Q, R, S, T are correct?
(A) S warmed with ammoniacal $AgNO_3$ gives a silver mirror
(B) Q with Cl_2(excess)/UV gives gammexane
(C) T is a heterocyclic compound
(D) R on acid-catalysed intramolecular cyclization then Zn-Hg/HCl gives 9,10-dihydroxyanthracene

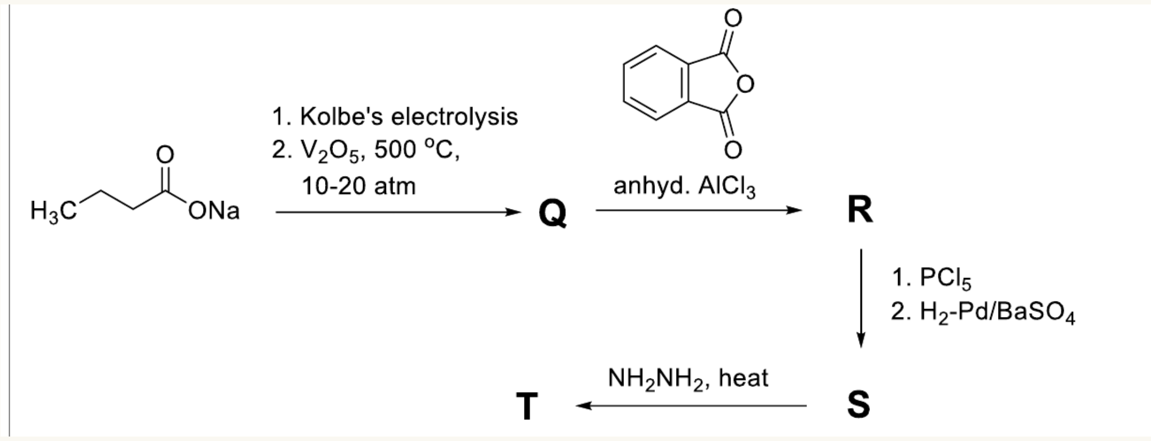


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Work through the sequence one arrow at a time, naming each product. Two clues fix things: phthalic anhydride + $AlCl_3$ is a Friedel–Crafts acylation (so Q must be benzene), and benzene + Cl_2/UV gives "gammexane".

Step 1: Identify the products.

Kolbe electrolysis followed by aromatisation over V_2O_5 gives **Q** = **benzene**. Benzene with phthalic anhydride and $AlCl_3$ (a Friedel–Crafts acylation) gives **R** = **2-benzoylbenzoic acid**. PCl_5 converts the −COOH into −COCl; then H_2 with Pd/$BaSO_4$ (the Rosenmund reduction) converts −COCl into −CHO, giving **S** = **2-benzoylbenzaldehyde**. Finally S with hydrazine and heat joins both carbonyl groups into one ring, giving **T** = **1-phenylphthalazine**.

(A)

S has a −CHO (aldehyde) group, and aldehydes give a positive Tollens test — a silver mirror. **TRUE.**

(B)

Benzene + Cl_2(excess) under UV gives $C_6H_6Cl_6$ (benzene hexachloride), commonly called gammexane. **TRUE.**

(C)

T (1-phenylphthalazine) has nitrogen atoms inside a ring — it is a heterocyclic compound. **TRUE.**

(D)

R cyclises to anthraquinone; Zn-Hg/HCl (Clemmensen reduction) converts C=O to CH_2, giving anthracene — *not* 9,10-dihydroxyanthracene. **FALSE.**

Final Answer: (A), (B), (C)

Q.9 *Section 3 • Numerical answer • +4/0*

Two cylinders, each with a frictionless piston, hold mixtures of He and Ar. In cylinder 1 the masses are m_1 (He) and m_2 (Ar); in cylinder 2 they are m_2 (He) and m_1 (Ar). The molar mass of Ar is 10 times that of He. The external pressure on cylinder 1 must be 5 times that on cylinder 2 so that the two gas volumes are equal at the same temperature. Find m_1/m_2.

How to think about it: At equal volume and temperature, pressure is proportional to the number of moles. Convert each mass to moles using molar mass.

Step 1: Moles in each cylinder.

Let molar mass of He $= M$, so Ar $= 10M$.

$$n_1 = \frac{m_1}{M} + \frac{m_2}{10M}, \qquad n_2 = \frac{m_2}{M} + \frac{m_1}{10M}.$$

Step 2: Use the pressure ratio.

$\dfrac{P_1}{P_2} = \dfrac{n_1}{n_2} = 5$, so

$$\frac{10m_1 + m_2}{10m_2 + m_1} = 5 \;\Rightarrow\; 10m_1 + m_2 = 50m_2 + 5m_1 \;\Rightarrow\; 5m_1 = 49m_2.$$

Step 3: Answer.

$\dfrac{m_1}{m_2} = \dfrac{49}{5} = 9.8.$

Final Answer: 9.8

Q.10 *Section 3 • Numerical answer • +4/0*

The total number of all possible isomers for the square-planar complex $K[M(NCS)(NO_2)(gly)]$ is ____________.
(gly $= NH_2CH_2COO^-$)

How to think about it: Count two kinds of isomerism and multiply: geometric isomers (the arrangement of ligands) and linkage isomers (NCS and NO_2 can each bond through two different atoms).

Step 1: Geometric isomers.

Glycinate is a bidentate ligand that occupies two neighbouring (*cis*) positions, with one end N and the other end O. The two single-atom ligands NCS^- and NO_2^- take the remaining two positions. There are **2** ways: which one sits opposite the N-end versus the O-end.

Step 2: Linkage isomers.

NCS^- can bond through N or through S — **2** ways. NO_2^- can bond through N (nitro) or through O (nitrito) — **2** ways.

Step 3: Multiply.

Square-planar complexes are flat, so they have no optical isomers. Total $= 2 \times 2 \times 2 = 8$.

Final Answer: 8

Q.11 *Section 3 • Numerical answer • +4/0*

The sum of the total number of carbonyl groups (>C=O) present in the major products X and Y is ____________.
(X: heating 2,4-dimethyl-3-oxopentanedioic acid; Y: heating an oxo-cyclopentane bearing two adjacent $-CO_2H$ groups.)

How to think about it: Two heating reactions to know: a β-keto acid loses CO_2 (decarboxylation); a pair of carboxylic acids on neighbouring carbons loses water to form a cyclic anhydride.

Product X.

In 2,4-dimethyl-3-oxopentanedioic acid, both $-CO_2H$ groups sit next to the central ketone (they are β-keto acids), so both lose CO_2 on heating. The product is pentan-3-one ($CH_3CH_2COCH_2CH_3$): **1 carbonyl**.

Product Y.

The two $-CO_2H$ groups are on adjacent ring carbons (and not next to the ketone), so on heating they lose water and form a cyclic anhydride. Y therefore keeps the ring ketone (1 C=O) plus the anhydride (2 C=O): **3 carbonyls**.

Sum.

$1 + 3 = 4$.

Final Answer: 4

Q.12 *Section 3 • Numerical answer • +4/0*

Treatment of buta-1,3-diyne with $NaNH_2$ (2 equivalents), followed by reaction with excess 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 ____________.

How to think about it: Both terminal alkyne hydrogens are acidic; 2 equivalents of $NaNH_2$ remove both. The resulting di-anion is alkylated at both ends. Triple bonds force atoms into a straight line.

Step 1: Build X.

Both ≡C–H ends are deprotonated and then alkylated by the crotyl bromide:

$$X = CH_3\text{-}CH{=}CH\text{-}CH_2\text{-}C{\equiv}C\text{-}C{\equiv}C\text{-}CH_2\text{-}CH{=}CH\text{-}CH_3.$$

Step 2: Find the straight-line part.

Every *sp* carbon of a triple bond has its two bonds at 180°. In the conjugated diyne $-CH_2$–C≡C–C≡C–CH_2-, all four diyne carbons lie on one line, and each *sp* carbon also pulls its neighbour onto that line — so the two flanking CH_2 carbons are on it too.

Step 3: Count.

That straight line passes through **6** carbon atoms (2 CH_2 carbons + 4 diyne carbons).

Final Answer: 6

Q.13 *Section 4 • Matching List •* +4/ − 1

Match each process in List-I with the correct combination of enthalpy and entropy changes in List-II, then choose the correct option.

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

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

Reasoning.

(P) Physisorption: adsorption releases heat ($\Delta H < 0$) and gas molecules become more ordered on the surface ($\Delta S < 0$) → (2).
(Q) Diamond → Graphite: graphite is more stable, so heat is released ($\Delta H < 0$), and graphite is more disordered ($\Delta S > 0$) → (5).

(R) Denaturation of protein: unfolding needs energy ($\Delta H > 0$) and increases disorder ($\Delta S > 0$) → (1).
(S) Propene → Cyclopropane: the strained ring is higher in energy ($\Delta H > 0$) and more rigid, hence lower entropy ($\Delta S < 0$) → (4).

Final Answer: (C) P→2, Q→5, R→1, S→4

Q.14 *Section 4 • Matching List •* +4/ − 1

For the species $SOCl_2$, $XeOF_4$, ClF_3, ClF_5, XeF_5^+, SO_3^{2-}, XeF_3^+, SF_4: match each molecular shape in List-I with the number of species having that shape in List-II, then 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

How to think about it: Use VSEPR: count bonding pairs and lone pairs around the central atom to get the "steric number", which fixes the shape.

Find each shape.

$SOCl_2$ — trigonal pyramidal; $XeOF_4$ — square pyramidal; ClF_3 — T-shaped; ClF_5 — square pyramidal; XeF_5^+ — square pyramidal; SO_3^{2-} — trigonal pyramidal; XeF_3^+ — T-shaped; SF_4 — see-saw.

Count for each List-I shape.

(P) See-saw: only SF_4 — **one** → (1).
(Q) T-shaped: ClF_3, XeF_3^+ — **two** → (2).
(R) Trigonal planar: none of the listed species — **zero** → (5).
(S) Square pyramidal: $XeOF_4$, ClF_5, XeF_5^+ — **three** → (3).

Final Answer: (A) P→1, Q→2, R→5, S→3

Q.15 *Section 4 • Matching List* • +4/ − 1

List-II contains products obtained from the compounds in List-I on reaction with O_3/Zn-H_2O followed by cyclization (via the more stable enolate) in aqueous NaOH. Match each bicyclic compound (P, Q, R, S) with the correct product structure.

(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

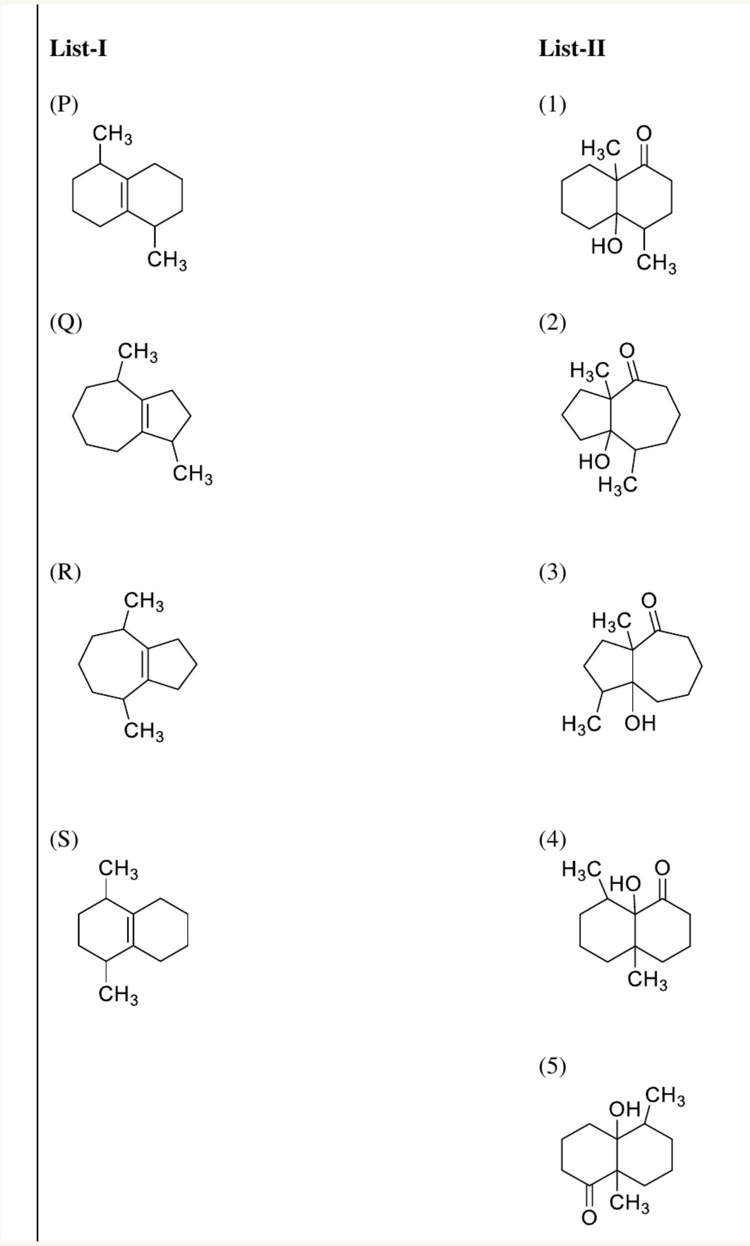


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: O_3/Zn-H_2O cuts the C=C double bond, turning it into two carbonyl groups; aqueous NaOH then drives an intramolecular aldol reaction (using the more stable enolate) that closes a new ring, giving a β-hydroxy ketone.

Reasoning.

Each List-I ring compound is opened by ozonolysis into a di-carbonyl, which re-closes by an aldol step into a bicyclic hydroxy-ketone. The product's ring sizes and the positions of the methyl groups depend on exactly where the new bond forms.

[Please verify with the official answer key:] Matching the four substrates to their products means tracking ring sizes, methyl positions and stereochemistry through the ozonolysis and aldol steps — intricate work. The tentative answer is option (A); please confirm with the official key.

Final Answer: (A) P→2, Q→4, R→1, S→3 (tentative)

Q.16 *Section 4 • Matching List • +4/ − 1*

Match the four reactions in List-I (oxime / O-acyl oxime derivatives of *o*-bromo-nitro aryl carbonyl compounds treated with base, shown in the figure below) with the major-product structures in List-II, then choose the correct option.

List-I	List-II
(P) Reaction (P) in the figure below	(1) *o*-cyanophenol
(Q) Reaction (Q) in the figure below	(2) *o*-bromobenzonitrile
(R) Reaction (R) in the figure below	(3) an *N*-aryl acetamide
(S) Reaction (S) in the figure below	(4) a 3-methyl-1,2-benzisoxazole
	(5) the free ketoxime

(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

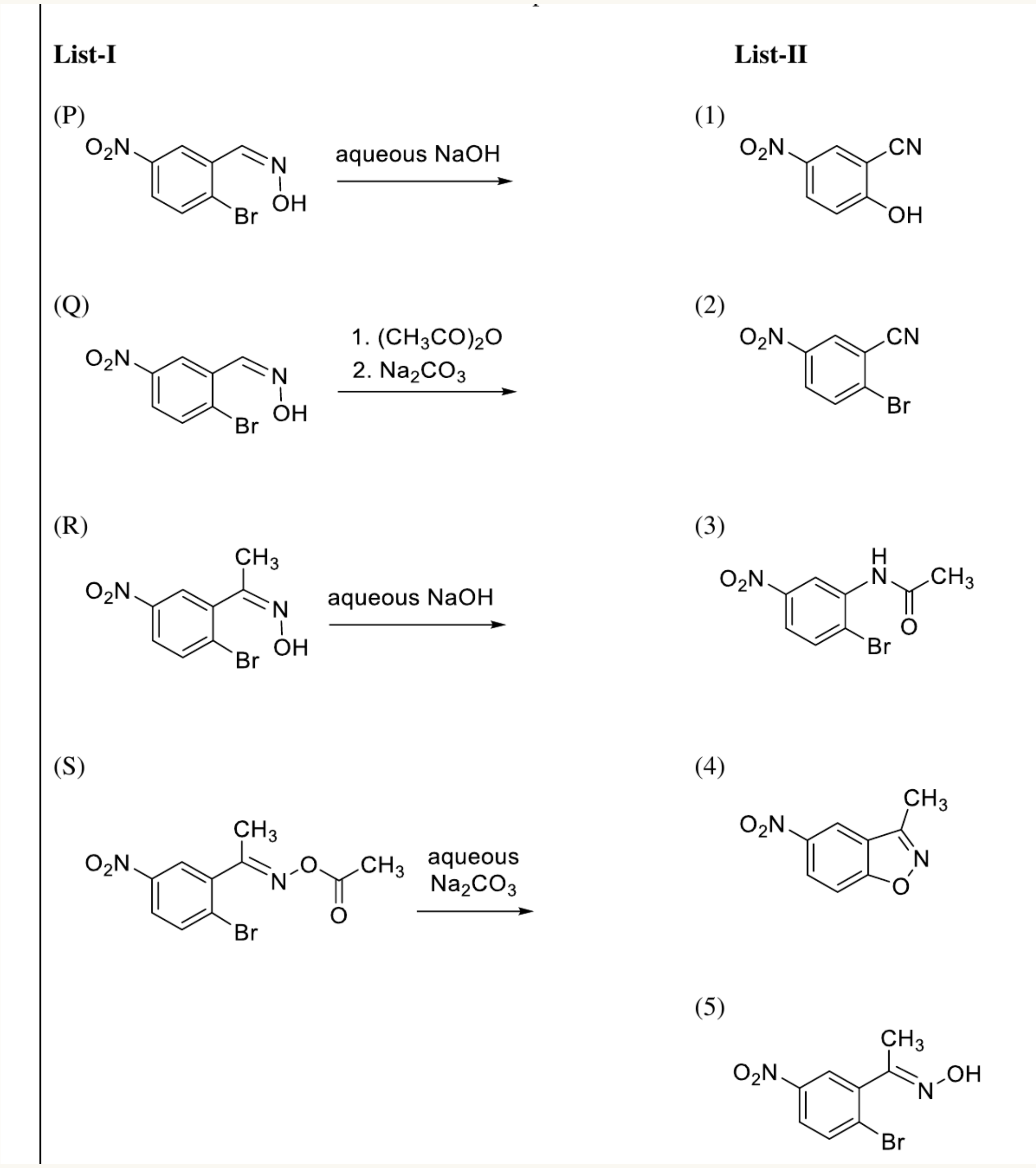


Figure from the original JEE (Advanced) 2026 Paper 1.

How to think about it: Three reactions to recognise: an aldoxime can lose water to become a nitrile; an *o*-halo aryl oxime can cyclise (the oxime oxygen kicks out the ring halide) to a benzisoxazole; a mild base hydrolyses an O-acetyl oxime back to the free oxime.

(P)

The *o*-bromo aryl *aldoxime* with aqueous NaOH: it loses water to give the nitrile, and the strong base also replaces the activated ring −Br by −OH, giving *o*-cyanophenol → (1).

(Q)

The same aldoxime with acetic anhydride then Na_2CO_3: the standard aldoxime→nitrile dehydration; the mild base leaves the C–Br untouched, giving *o*-bromobenzonitrile → (2).

(R)

The *o*-bromo aryl *ketoxime* with aqueous NaOH: the oxime oxygen attacks the ring carbon bearing Br and displaces it, closing a ring — giving a 3-methyl-1,2-benzisoxazole → (4).

(S)

The O-acetyl ketoxime with mild aqueous Na_2CO_3: the mild base simply hydrolyses off the acetyl group, regenerating the free ketoxime → (5).

Final Answer: (B) P→1, Q→2, R→4, S→5

CONSOLIDATED ANSWER KEY (all 48 questions)

Q	Mathematics	Physics	Chemistry
1	(D)	(C)	(B) [600R]
2	(C)	(C)	(C)
3	(B)	(B)	(A)
4	(C)	(A)	(A) †
5	(A),(C)	(A),(C)	(A),(B),(D)
6	(A),(D)	(A),(B)	(A),(C)
7	(B),(D)	(A),(B),(C)	(B),(C)
8	(A),(C),(D)	(A),(C)	(A),(B),(C)
9	2520	$\sqrt{3} \approx 1.73$	9.8
10	5	$1/3 \approx 0.33$	8
11	206	≈ 0.66	4
12	4	0.5	6
13	(C)	(C) †	(C)
14	(B)	(A)	(A)
15	(A)	(C) †	(A) †
16	(B)	(A)	(B)

† **Please verify with the official key** — Physics Q13 & Q15 and Chemistry Q4 & Q15 are the most intricate questions in the paper (tube-network path lengths, induced-current shapes, cyclobutane stereochemistry, ozonolysis-product matching) and are the least certain answers here.

Note. This is an independently prepared solutions booklet meant as a study aid. JEE (Advanced) is a tough exam and even careful work can contain slips, so please cross-check every answer against the official IIT key when it is released — especially the four flagged (†) questions. All figures in this booklet are the actual figures from the original question paper.