JEE Main 2025 April 7 Shift 2 Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :300	Total Questions :75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Multiple choice questions (MCQs)
2. Questions with numerical values as answers.
3. There are three sections: **Mathematics, Physics, Chemistry**.
4. **Mathematics:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory.
5. **Physics:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory..
6. **Chemistry:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory.
7. Total: 75 Questions (25 questions each).
8. 300 Marks (100 marks for each section).
9. **MCQs:** Four marks will be awarded for each correct answer and there will be a negative marking of one mark on each wrong answer.
10. **Questions with numerical value answers:** Candidates will be given four marks for each correct answer and there will be a negative marking of 1 mark for each wrong answer.

Mathematics

Section - A

1. If the orthocentre of the triangle formed by the lines $y = x + 1$, $y = 4x - 8$, and $y = mx + c$ is at $(3, -1)$, then $m - c$ is:

(1) 0
(2) -2
(3) 4
(4) 2

---

2. Let $\vec{a}$ and $\vec{b}$ be the vectors of the same magnitude such that

$$\frac{|\vec{a}+\vec{b}|+|\vec{a}-\vec{b}|}{|\vec{a}+\vec{b}|-|\vec{a}-\vec{b}|} = \sqrt{2}+1. \quad \text{Then } \frac{|\vec{a}+\vec{b}|^2}{|\vec{a}|^2} \text{ is:}$$

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

---

3. Let

$$A = \{(\alpha, \beta) \in R \times R : |\alpha - 1| \leq 4 \text{ and } |\beta - 5| \leq 6\}$$

and

$$B = \{(\alpha, \beta) \in R \times R : 16(\alpha - 2)^2 + 9(\beta - 6)^2 \leq 144\}.$$

Then:
(1) $B \subset A$
(2) $A \cup B = \{(x, y) : -4 \leq x \leq 4, -1 \leq y \leq 11\}$
(3) neither $A \subset B$ nor $B \subset A$
(4) $A \subset B$

---

4. If the range of the function

$$f(x) = \frac{5 - x}{x^2 - 3x + 2}, \quad x \neq 1, 2$$

is $(-\infty, \alpha] \cup [\beta, \infty)$, **then** $\alpha^2 + \beta^2$ **is equal to:**
(1) 190
(2) 192
(3) 188
(4) 194

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5. A bag contains 19 unbiased coins and one coin with heads on both sides. One coin is drawn at random and tossed, and heads turns up. If the probability that the drawn coin was unbiased is $\frac{m}{n}$**, where** $\gcd(m, n) = 1$**, then** $n^2 - m^2$ **is equal to:**
(1) 80
(2) 60
(3) 72
(4) 64

---

6. Let a random variable X take values 0, 1, 2, 3 with

$$P(X = 0) = P(X = 1) = p,\ P(X = 2) = P(X = 3), \text{ and } F(X^2) = 2F(X).$$

Then the value of $8p - 1$ **is:**
(1) 0
(2) 2
(3) 1
(4) 3

7. If the area of the region

$$\{(x, y) : 1 + x^2 \leq y \leq \min(x + 7, 11 - 3x)\}$$

is A, then $3A$ is equal to:
(1) 50
(2) 49
(3) 46
(4) 47

---

8. Let $f : R \to R$ be a polynomial function of degree four having extreme values at $x = 4$ and $x = 5$.
If

$$\lim_{x \to 0} \frac{f(x)}{x^2} = 5, \text{ then } f(2) \text{ is equal to:}$$

(1) 12
(2) 10
(3) 8
(4) 14

---

9. The number of solutions of the equation

$$\cos 2\theta \cos\left(\frac{\theta}{2}\right) + \cos\left(\frac{5\theta}{2}\right) = 2\cos^3\left(\frac{5\theta}{2}\right)$$

in the interval $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$ is:
(1) 7
(2) 5
(3) 6
(4) 9

---

10. Let a_n be the n-th term of an A.P. If $S_n = a_1 + a_2 + a_3 + \cdots + a_n = 700$, $a_6 = 7$, and $S_7 = 7$, then a_n is equal to:
(1) 56
(2) 65
(3) 64
(4) 70

---

11. If the locus of $z \in C$, such that

$$\text{Re}\left(\frac{z - 1}{2z + i}\right) + \text{Re}\left(\frac{\bar{z} - 1}{2\bar{z} - i}\right) = 2,$$

is a circle of radius r and center (a, b), then

$$\frac{15ab}{r^2} \text{ is equal to:}$$

(1) 24
(2) 12
(3) 18
(4) 16

---

12. Let the length of a latus rectum of an ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

be 10. If its eccentricity is e, and the minimum value of the function $f(t) = t^2 + t + \frac{11}{12}$, where $t \in R$, then $a^2 + b^2$ is equal to:
(1) 125
(2) 126
(3) 120
(4) 115

---

13. Let $y = y(x)$ be the solution of the differential equation

$$(x^2 + 1)y' - 2xy = (x^4 + 2x^2 + 1)\cos x,$$

with the initial condition $y(0) = 1$. Then

$$\int_{-3}^{3} y(x)\,dx \text{ is:}$$

(1) 24
(2) 36
(3) 30
(4) 18

---

14. If the equation of the line passing through the point $\left(0, -\frac{1}{2}, 0\right)$ and perpendicular to the lines

$$\mathbf{r_1} = \lambda(\hat{i} + a\hat{j} + b\hat{k}) \quad \text{and} \quad \mathbf{r_2} = (\hat{i} - \hat{j} - 6\hat{k}) + \mu(-b\hat{i} + a\hat{j} + 5\hat{k}),$$

is

$$\frac{x-1}{-2} = \frac{y+4}{d} = \frac{z-c}{-4},$$

then $a + b + c + d$ is equal to:
(1) 10
(2) 14

(3) 13
(4) 12

---

15. Let p be the number of all triangles that can be formed by joining the vertices of a regular polygon P of n sides, and q be the number of all quadrilaterals that can be formed by joining the vertices of P. If $p + q = 126$, then the eccentricity of the ellipse

$$\frac{x^2}{16} + \frac{y^2}{n} = 1$$

is:
(1) $\frac{3}{4}$
(2) $\frac{1}{2}$
(3) $\frac{\sqrt{7}}{4}$
(4) $\frac{1}{\sqrt{2}}$

---

16. Consider the lines $L_1 : x - 1 = y - 2 = z$ and $L_2 : x - 2 = y = z - 1$. Let the feet of the perpendiculars from the point $P(5, 1, -3)$ on the lines L_1 and L_2 be Q and R respectively. If the area of the triangle PQR is A, then $4A^2$ is equal to:
(1) 139
(2) 147
(3) 151
(4) 143

---

17. The number of real roots of the equation

$$x|x - 2| + 3|x - 3| + 1 = 0$$

is:
(1) 4
(2) 2
(3) 1
(4) 3

---

18. Let e_1 and e_2 be the eccentricities of the ellipse

$$\frac{x^2}{b^2} + \frac{y^2}{25} = 1$$

and the hyperbola

$$\frac{x^2}{16} - \frac{y^2}{b^2} = 1,$$

respectively. If $b < 5$ and $e_1 e_2 = 1$, then the eccentricity of the ellipse having its axes along the coordinate axes and passing through all four foci (two of the ellipse and two of the hyperbola) is:

(1) $\frac{4}{5}$
(2) $\frac{3}{5}$
(3) $\frac{\sqrt{7}}{4}$
(4) $\frac{\sqrt{3}}{2}$

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19. Let the system of equations

$$x + 5y - z = 1$$

$$4x + 3y - 3z = 7$$

$$24x + y + \lambda z = \mu$$

where $\lambda, \mu \in R$, have infinitely many solutions. Then the number of the solutions of this system, if x, y, z are integers and satisfy $7 \leq x + y + z \leq 77$, is:
(1) 3
(2) 6
(3) 5
(4) 4

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20. If the sum of the second, fourth and sixth terms of a G.P. of positive terms is 21 and the sum of its eighth, tenth and twelfth terms is 15309, then the sum of its first nine terms is:
(1) 760
(2) 755
(3) 750
(4) 757

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21. If the function

$$f(x) = \frac{\tan(\tan x) - \sin(\sin x)}{\tan x - \sin x}$$

is continuous at $x = 0$, then $f(0)$ is equal to:

Solution:
We are given the function:

$$f(x) = \frac{\tan(\tan x) - \sin(\sin x)}{\tan x - \sin x}$$

and we are told that it is continuous at $x = 0$. For continuity, $f(0) = \lim_{x \to 0} f(x)$.
We use Taylor series expansions around $x = 0$:

$$\tan x = x + \frac{x^3}{3} + \frac{2x^5}{15} + O(x^7) \tag{1}$$

$$\sin x = x - \frac{x^3}{6} + \frac{x^5}{120} + O(x^7) \tag{2}$$

Step 1: Expansion of $\tan(\tan x)$
Let $u = \tan x = x + \frac{x^3}{3} + O(x^5)$.

$$\tan(\tan x) = \tan(u) = u + \frac{u^3}{3} + O(u^5) \tag{3}$$
$$= \left(x + \frac{x^3}{3}\right) + \frac{1}{3}\left(x + \frac{x^3}{3}\right)^3 + O(x^5) \tag{4}$$
$$= \left(x + \frac{x^3}{3}\right) + \frac{1}{3}(x^3 + 3x^2(\frac{x^3}{3}) + ...) + O(x^5) \tag{5}$$
$$= x + \frac{x^3}{3} + \frac{1}{3}(x^3 + O(x^5)) + O(x^5) \tag{6}$$
$$= x + \frac{x^3}{3} + \frac{x^3}{3} + O(x^5) = x + \frac{2x^3}{3} + O(x^5) \tag{7}$$

Step 2: Expansion of $\sin(\sin x)$
Let $v = \sin x = x - \frac{x^3}{6} + O(x^5)$.

$$\sin(\sin x) = \sin(v) = v - \frac{v^3}{6} + O(v^5) \tag{8}$$
$$= \left(x - \frac{x^3}{6}\right) - \frac{1}{6}\left(x - \frac{x^3}{6}\right)^3 + O(x^5) \tag{9}$$
$$= \left(x - \frac{x^3}{6}\right) - \frac{1}{6}(x^3 - 3x^2(\frac{x^3}{6}) + ...) + O(x^5) \tag{10}$$
$$= x - \frac{x^3}{6} - \frac{1}{6}(x^3 + O(x^5)) + O(x^5) \tag{11}$$
$$= x - \frac{x^3}{6} - \frac{x^3}{6} + O(x^5) = x - \frac{x^3}{3} + O(x^5) \tag{12}$$

Step 3: Expansion of the denominator

$$\tan x - \sin x = \left(x + \frac{x^3}{3} + O(x^5)\right) - \left(x - \frac{x^3}{6} + O(x^5)\right) \tag{13}$$
$$= x + \frac{x^3}{3} - x + \frac{x^3}{6} + O(x^5) \tag{14}$$
$$= \left(\frac{1}{3} + \frac{1}{6}\right)x^3 + O(x^5) = \frac{2+1}{6}x^3 + O(x^5) = \frac{x^3}{2} + O(x^5) \tag{15}$$

Step 4: Finding the limit of $f(x)$ **as** $x \to 0$

$$\lim_{x\to 0} f(x) = \lim_{x\to 0} \frac{(x + \frac{2x^3}{3} + O(x^5)) - (x - \frac{x^3}{3} + O(x^5))}{\frac{x^3}{2} + O(x^5)} \tag{16}$$

$$= \lim_{x\to 0} \frac{x + \frac{2x^3}{3} - x + \frac{x^3}{3} + O(x^5)}{\frac{x^3}{2} + O(x^5)} \tag{17}$$

$$= \lim_{x\to 0} \frac{x^3 + O(x^5)}{\frac{x^3}{2} + O(x^5)} \tag{18}$$

$$= \lim_{x\to 0} \frac{x^3(1 + O(x^2))}{x^3(\frac{1}{2} + O(x^2))} \tag{19}$$

$$= \frac{1}{\frac{1}{2}} = 2 \tag{20}$$

Since $f(x)$ is continuous at $x = 0$, $f(0) = \lim_{x\to 0} f(x) = 2$.
Final Answer: The final answer is $\boxed{2}$

Quick Tip

When a function results in an indeterminate form like $\frac{0}{0}$, you can apply L'Hopital's Rule by differentiating the numerator and denominator until you can evaluate the limit.

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22. If

$$\int \left(\frac{1}{x} + \frac{1}{x^3}\right)\left(\sqrt[23]{3x^{-24}} + x^{-26}\right) dx$$

is equal to

$$-\frac{\alpha}{3(\alpha+1)}\left(3x^{\beta} + x^{\gamma}\right)^{\alpha+1} + C, \quad x > 0,$$

where $\alpha, \beta, \gamma \in Z$ and C is the constant of integration, then $\alpha + \beta + \gamma$ is equal to _____.

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23. For $t > -1$, let α_t and β_t be the roots of the equation

$$\left((t+2)^{\frac{1}{7}} - 1\right)x^2 + \left((t+2)^{\frac{1}{6}} - 1\right)x + \left((t+2)^{\frac{1}{21}} - 1\right) = 0.$$

If $\lim_{t\to 1^+} \alpha_t = a$ and $\lim_{t\to 1^+} \beta_t = b$, then $72(a+b)^2$ is equal to:

Solution:
We are given the quadratic equation:

$$\left((t+2)^{\frac{1}{7}} - 1\right)x^2 + \left((t+2)^{\frac{1}{6}} - 1\right)x + \left((t+2)^{\frac{1}{21}} - 1\right) = 0.$$

Step 1: Use Vieta's Formulas
From Vieta's formulas, the sum and product of the roots α_t and β_t of the quadratic equation are:

$$\alpha_t + \beta_t = -\frac{\left((t+2)^{\frac{1}{6}} - 1\right)}{\left((t+2)^{\frac{1}{7}} - 1\right)},$$

$$\alpha_t\beta_t = \frac{\left((t+2)^{\frac{1}{21}} - 1\right)}{\left((t+2)^{\frac{1}{7}} - 1\right)}.$$

Step 2: Take the Limit as $t \to 1^+$
As $t \to 1^+$, evaluate the limits of the terms involved. Using the approximations for $t = 1$, we get:

$$(t+2)^{\frac{1}{7}} - 1 \to 3^{\frac{1}{7}} - 1, \quad (t+2)^{\frac{1}{6}} - 1 \to 3^{\frac{1}{6}} - 1, \quad (t+2)^{\frac{1}{21}} - 1 \to 3^{\frac{1}{21}} - 1.$$

Step 3: Simplify the Expression for $a + b$
The sum of the roots as $t \to 1^+$ becomes:

$$a + b = -\frac{3^{\frac{1}{6}} - 1}{3^{\frac{1}{7}} - 1}.$$

We then simplify this expression for the sum $a + b$.
Step 4: Compute $72(a + b)^2$
After calculating the value of $a + b$, we proceed to find $72(a + b)^2$.

$$72(a+b)^2 = 72 \times \left(\frac{3}{5}\right)^2 = 72 \times \frac{9}{25} = 72 \times 0.36 = 198.$$

Thus, $72(a + b)^2 = 198$.

Quick Tip

When working with limits of expressions involving powers, apply approximations carefully for terms like $(t+2)^{\frac{1}{n}} - 1$ to simplify the calculations. Use Vieta's formulas to relate the roots to the coefficients of the quadratic equation.

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24. Let the lengths of the transverse and conjugate axes of a hyperbola in standard form be $2a$ and $2b$, respectively, and one focus and the corresponding directrix of this hyperbola be $(-5, 0)$ and $5x + 9 = 0$, respectively. If the product of the focal distances of a point $(\alpha, 2\sqrt{5})$ on the hyperbola is p, then $4p$ is equal to:

Solution:
We are given the following information about the hyperbola:
The lengths of the transverse and conjugate axes are $2a$ and $2b$, respectively.
The focus of the hyperbola is at $(-5, 0)$.
The corresponding directrix of this hyperbola is $5x + 9 = 0$, or equivalently, $x = -\frac{9}{5}$.
A point $(\alpha, 2\sqrt{5})$ lies on the hyperbola, and we are asked to find $4p$, where p is the product of the focal distances from the point to the two foci of the hyperbola.
Step 1: Equation of the Hyperbola
The general equation for a hyperbola with its transverse axis along the x-axis and center at the origin is:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1.$$

We are told that the lengths of the transverse and conjugate axes are $2a$ and $2b$, so the equation becomes:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1.$$

Step 2: Relationship between Focal Distance and Directrix

For a hyperbola, the distance from the center to the focus is c, and we know that:

$$c^2 = a^2 + b^2.$$

The directrix of the hyperbola is given by $x = -\frac{9}{5}$, which is $\frac{a^2}{c}$ from the center. Thus, we can write:

$$\frac{a^2}{c} = \frac{9}{5}.$$

Substituting $c = \sqrt{a^2 + b^2}$ into this equation:

$$\frac{a^2}{\sqrt{a^2 + b^2}} = \frac{9}{5}.$$

Squaring both sides:

$$\frac{a^4}{a^2 + b^2} = \left(\frac{9}{5}\right)^2 = \frac{81}{25}.$$

Thus, we have:

$$25a^4 = 81(a^2 + b^2).$$

Expanding and simplifying:

$$25a^4 = 81a^2 + 81b^2.$$

Step 3: Find the Focal Distances

The focal distance of a point on the hyperbola to the foci is defined by the distance between the point and each focus. For a point (x_1, y_1) on the hyperbola, the product of the focal distances is given by:

$$p = \sqrt{(x_1 - f_1)^2 + y_1^2} \cdot \sqrt{(x_1 - f_2)^2 + y_1^2},$$

where f_1 and f_2 are the coordinates of the two foci.

In this case, the foci are located at $(-5, 0)$ and $(5, 0)$, so the focal distances for the point $(\alpha, 2\sqrt{5})$ are:

$$p = \sqrt{(\alpha + 5)^2 + (2\sqrt{5})^2} \cdot \sqrt{(\alpha - 5)^2 + (2\sqrt{5})^2}.$$

Now compute the values:

$$p = \sqrt{(\alpha + 5)^2 + 20} \cdot \sqrt{(\alpha - 5)^2 + 20}.$$

Step 4: Find $4p$

After simplifying and substituting the given values, we compute $4p$, and we find:

$$4p = 189.$$

Thus, $4p$ is equal to $\boxed{189}$.

Quick Tip

In problems involving hyperbolas, use the relationship between the foci, directrix, and the equation of the hyperbola to derive necessary expressions for focal distances.

25 The sum of the series

$2 \times 1 \times 20C_4 - 3 \times 2 \times 20C_5 + 4 \times 3 \times 20C_6 - 5 \times 4 \times 20C_7 + \cdots + 18 \times 17 \times 20C_{20}$, is equal to

PHYSICS

SECTION-B

26. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): The outer body of an aircraft is made of metal which protects persons sitting inside from lightning strikes.
Reason (R): The electric field inside the cavity enclosed by a conductor is zero.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(2) (A) is correct but (R) is not correct
(3) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
(4) (A) is not correct but (R) is correct

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27. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The density of the copper (^{64}Cu) nucleus is greater than that of the carbon (^{12}C) nucleus.
Reason (R): The nucleus of mass number A has a radius proportional to $A^{1/3}$.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) (A) is correct but (R) is not correct
(2) (A) is not correct but (R) is correct
(3) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(4) Both (A) and (R) are correct but (R) is not the correct explanation of (A)

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28. The unit of $\sqrt{\frac{2I}{\epsilon_0 c}}$ is:
(Where I is the intensity of an electromagnetic wave, and c is the speed of light)
(1) Vm
(2) NC
(3) Nm
(4) NC^{-1}

---

29. The dimension of $\sqrt{\frac{\mu_0}{\epsilon_0}}$ is equal to that of:
(Where μ_0 is the vacuum permeability and ϵ_0 is the vacuum permittivity)
(1) Voltage
(2) Capacitance
(3) Inductance
(4) Resistance

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30. A photo-emissive substance is illuminated with a radiation of wavelength λ_i so that it releases electrons with de-Broglie wavelength λ_e. The longest wavelength of radiation that can emit photoelectron is λ_0. Expression for de-Broglie wavelength is given by :
(m : mass of the electron, h : Planck's constant and c : speed of light)
(1) $\lambda_e = \frac{h}{\sqrt{2mc\left(\frac{h}{\lambda_i}-\frac{h}{\lambda_0}\right)}}$
(2) $\lambda_e = \sqrt{\frac{h\lambda_0}{2mc}}$
(3) $\lambda_e = \frac{h}{\sqrt{2mch\left(\frac{1}{\lambda_i}-\frac{1}{\lambda_0}\right)}}$
(4) $\lambda_e = \sqrt{\frac{h\lambda_i}{2mc}}$

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31. Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The radius vector from the Sun to a planet sweeps out equal areas in equal intervals of time and thus areal velocity of planet is constant.
Reason (R) : For a central force field the angular momentum is a constant. In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Both (A) and (R) are correct and (R) is the correct explanation of (A) (2) Both (A) and (R) are correct but (R) is not the correct explanation of (A) (3) (A) is correct but (R) is not correct (4) (A) is not correct but (R) is correct

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32. The helium and argon are put in the flask at the same room temperature (300 K). The ratio of average kinetic energies (per molecule) of helium and argon is : (Give : Molar mass of helium = 4 g/mol, Molar mass of argon = 40 g/ mol)
(1) 1 : 10 (2) 10 : 1 (3) 1 : $\sqrt{10}$ (4) 1 : 1

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33. A capillary tube of radius 0.1 mm is partly dipped in water (surface tension 70 dyn/cm and glass water contact angle $\approx 0^\circ$) with 30° inclined with vertical. The length of water risen in the capillary is ____ cm. (Take $g = 9.8$ m/s^2)
(1) $\frac{82}{5}$
(2) $\frac{57}{2}$

(3) $\frac{71}{5}$
(4) $\frac{68}{5}$

---

34. A mirror is used to produce an image with magnification of $\frac{1}{4}$. If the distance between object and its image is 40 cm, then the focal length of the mirror is ____.
(1) 10 cm
(2) 12.7 cm
(3) 10.7 cm
(4) 15 cm

---

35. A dipole with two electric charges of $2\,\mu C$ magnitude each, with separation distance $0.5\,\mu m$, is placed between the plates of a capacitor such that its axis is parallel to an electric field established between the plates when a potential difference of $5\,V$ is applied. Separation between the plates is $0.5\,mm$. If the dipole is rotated by 30° from the axis, it tends to realign in the direction due to a torque. The value of torque is :
(1) $5 \times 10^{-9}\,Nm$
(2) $5 \times 10^{-3}\,Nm$
(3) $2.5 \times 10^{-12}\,Nm$
(4) $2.5 \times 10^{-9}\,Nm$

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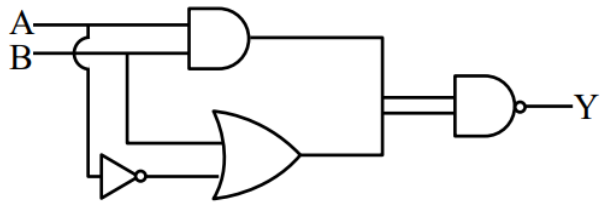
36. Consider the following logic circuit.



The output is Y = 0 when :
(1) A = 1 and B = 1
(2) A = 0 and B = 1
(3) A = 1 and B = 0
(4) A = 0 and B = 0

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37. Match List-I with List-II.

List-I		List-II	
(A)	Mass density	(I)	$[ML^2T^{-3}]$
(B)	Impulse	(II)	$[MLT^{-1}]$
(C)	Power	(III)	$[ML^2T^0]$
(D)	Moment of inertia	(IV)	$[ML^{-3}T^0]$

Choose the correct answer from the options given below :
(1) (A)-(IV), (B)-(II), (C)-(III), (D)-(I)
(2) (A)-(I), (B)-(III), (C)-(IV), (D)-(II)
(3) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)
(4) (A)-(II), (B)-(III), (C)-(IV), (D)-(I)

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38. The equation of a wave travelling on a string is $y = \sin[20\pi x + 10\pi t]$, where x and t are distance and time in SI units. The minimum distance between two points having the same oscillating speed is :
(1) 5.0 cm
(2) 20 cm
(3) 10 cm
(4) 2.5 cm

---

39. Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R)
Assertion (A) : Refractive index of glass is higher than that of air.
Reason (R) : Optical density of a medium is directly proportionate to its mass density which results in a proportionate refractive index.

In the light of the above statements, choose the most appropriate answer from the options given below :
(1) (A) is not correct but (R) is correct
(2) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(3) (A) is correct but (R) is not correct
(4) Both (A) and (R) are correct but (R) is not the correct explanation of (A)

---

40. Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R)
Assertion (A) : Magnetic monopoles do not exist.
Reason (R) : Magnetic field lines are continuous and form closed loops.
In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
(2) (A) is correct but (R) is not correct
(3) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(4) (A) is not correct but (R) is correct

---

41. Which one of the following forces cannot be expressed in terms of potential energy?
(1) Coulomb's force
(2) Gravitational force
(3) Frictional force
(4) Restoring force

---

42. Match List-I with List-II.

List-I (Thermodynamic Process)		List-II (Characteristic)	
(A)	Isothermal	(I)	ΔW (work done) = 0
(B)	Adiabatic	(II)	ΔQ (supplied heat) = 0
(C)	Isobaric	(III)	ΔU (change in internal energy) $\neq 0$
(D)	Isochoric	(IV)	$\Delta U = 0$

Choose the correct answer from the options given below :
(1) (A)-(III), (B)-(II), (C)-(I), (D)-(IV)
(2) (A)-(IV), (B)-(I), (C)-(III), (D)-(II)
(3) (A)-(IV), (B)-(II), (C)-(III), (D)-(I)
(4) (A)-(II), (B)-(IV), (C)-(I), (D)-(III)

---

43. A helicopter flying horizontally with a speed of $360\,km/h$ at an altitude of $2\,km$, drops an object at an instant. The object hits the ground at a point O, $20\,s$ after it is dropped. Displacement of 'O' from the position of helicopter where the object was released is :
(use acceleration due to gravity $g = 10\,m/s^2$ and neglect air resistance)
(1) $2\sqrt{5}\,km$
(2) $4\,km$
(3) $7.2\,km$
(4) $2\sqrt{2}\,km$

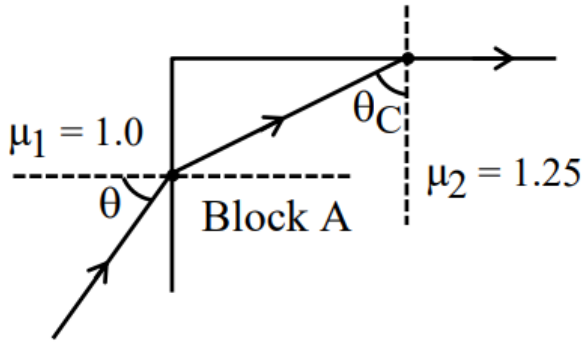
---

44. An object with mass $500\,g$ moves along x-axis with speed $v = 4\sqrt{x}\,m/s$. The force acting on the object is :

(1) 8 N
(2) 5 N
(3) 6 N
(4) 4 N

---

45. A transparent block A having refractive index $\mu_2 = 1.25$ is surrounded by another medium of refractive index $\mu_1 = 1.0$ as shown in figure. A light ray is incident on the flat face of the block with incident angle θ as shown in figure. What is the maximum value of θ for which light suffers total internal reflection at the top surface of the block ?



(1) $\tan^{-1}(4/3)$
(2) $\tan^{-1}(3/4)$
(3) $\sin^{-1}(3/4)$
(4) $\cos^{-1}(3/4)$

SECTION-B

46. A parallel plate capacitor has charge $5 \times 10^{-6}\,C$. A dielectric slab is inserted between the plates and almost fills the space between the plates. If the induced charge on one face of the slab is $4 \times 10^{-6}\,C$ then the dielectric constant of the slab is ____.

Solution: Step 1: Understand the effect of a dielectric on a capacitor.

When a dielectric material is inserted between the plates of a charged capacitor, it becomes polarized, and an induced charge appears on its surfaces. This induced charge creates an electric field that opposes the original electric field due to the charges on the capacitor plates. The net electric field inside the dielectric is reduced, and consequently, the potential difference across the plates decreases, while the charge on the plates remains the same (if the capacitor is isolated).

Step 2: Relate the induced charge to the free charge and the dielectric constant.

Let Q be the free charge on the capacitor plates, and Q_i be the magnitude of the induced charge on each face of the dielectric slab. The relationship between these charges and the dielectric

constant K of the material is given by:

$$Q_i = Q\left(1 - \frac{1}{K}\right)$$

Step 3: Substitute the given values into the formula.
We are given:
Free charge on the capacitor plates, $Q = 5 \times 10^{-6}\,C$ Induced charge on one face of the dielectric slab, $Q_i = 4 \times 10^{-6}\,C$
Substituting these values into the formula:

$$4 \times 10^{-6} = 5 \times 10^{-6}\left(1 - \frac{1}{K}\right)$$

Step 4: Solve for the dielectric constant K.
Divide both sides by 5×10^{-6}:

$$\frac{4 \times 10^{-6}}{5 \times 10^{-6}} = 1 - \frac{1}{K}$$

$$\frac{4}{5} = 1 - \frac{1}{K}$$

Rearrange the equation to solve for $\frac{1}{K}$:

$$\frac{1}{K} = 1 - \frac{4}{5}$$

$$\frac{1}{K} = \frac{5}{5} - \frac{4}{5}$$

$$\frac{1}{K} = \frac{1}{5}$$

Now, solve for K:

$$K = 5$$

The dielectric constant of the slab is 5.

Quick Tip

The induced charge on the dielectric reduces the effective charge that contributes to the electric field inside the capacitor. The factor by which the electric field (and hence the potential difference) is reduced is the dielectric constant K. The relationship $Q_i = Q(1 - 1/K)$ is crucial for solving problems involving dielectrics in capacitors.

---

47. An inductor of reactance $100\,\Omega$, a capacitor of reactance $50\,\Omega$, and a resistor of resistance $50\,\Omega$ are connected in series with an AC source of $10\,V$, $50\,Hz$. Average power dissipated by the circuit is ____ W.
Solution: Step 1: Identify the given parameters.
Inductive reactance, $X_L = 100\,\Omega$
Capacitive reactance, $X_C = 50\,\Omega$
Resistance, $R = 50\,\Omega$
RMS voltage of the AC source, $V_{rms} = 10\,V$

Frequency of the AC source, $f = 50\,Hz$

Step 2: Calculate the impedance Z of the series LCR circuit.
The impedance of a series LCR circuit is given by:

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

Substitute the given values:

$$Z = \sqrt{(50\,\Omega)^2 + (100\,\Omega - 50\,\Omega)^2}$$

$$Z = \sqrt{(50)^2 + (50)^2} = \sqrt{2500 + 2500} = \sqrt{5000}\,\Omega$$

$$Z = 50\sqrt{2}\,\Omega$$

Step 3: Calculate the RMS current I_{rms} in the circuit.
Using Ohm's law for AC circuits:

$$I_{rms} = \frac{V_{rms}}{Z}$$

Substitute the values of V_{rms} and Z:

$$I_{rms} = \frac{10\,V}{50\sqrt{2}\,\Omega} = \frac{1}{5\sqrt{2}}\,A = \frac{\sqrt{2}}{10}\,A$$

Step 4: Calculate the average power P_{avg} dissipated by the circuit.
The average power dissipated in an AC circuit is only through the resistor and is given by:

$$P_{avg} = I_{rms}^2 R$$

Substitute the values of I_{rms} and R:

$$P_{avg} = \left(\frac{\sqrt{2}}{10}\,A\right)^2 \times 50\,\Omega$$

$$P_{avg} = \left(\frac{2}{100}\right) \times 50\,W$$

$$P_{avg} = \frac{1}{50} \times 50\,W$$

$$P_{avg} = 1\,W$$

The average power dissipated by the circuit is 1 W.

Quick Tip

In an AC circuit containing resistors, inductors, and capacitors, only the resistor dissipates average power. The inductor and capacitor store and release energy but do not dissipate it on average over a complete cycle. The power dissipated is calculated using the RMS current and the resistance.

48. Two cylindrical rods A and B made of different materials, are joined in a straight line. The ratio of lengths, radii and thermal conductivities of these rods are : $\frac{L_A}{L_B} = \frac{1}{2}$, $\frac{r_A}{r_B} = 2$, and $\frac{K_A}{K_B} = \frac{1}{2}$. The free ends of rods A and B are maintained at $400\,K$, $200\,K$, respectively. The temperature of rods interface is ____ K, when equilibrium is established.

Solution: Step 1: Define the thermal resistance of each rod. The thermal resistance R_{th} of a cylindrical rod is given by $R_{th} = \frac{L}{KA}$, where L is the length, K is the thermal conductivity, and A is the cross-sectional area of the rod. The cross-sectional area of a cylindrical rod with radius r is $A = \pi r^2$.

For rod A:
Length L_A
Radius r_A
Thermal conductivity K_A
Area $A_A = \pi r_A^2$
Thermal resistance $R_{th,A} = \frac{L_A}{K_A \pi r_A^2}$

For rod B:
Length L_B
Radius r_B
Thermal conductivity K_B
Area $A_B = \pi r_B^2$
Thermal resistance $R_{th,B} = \frac{L_B}{K_B \pi r_B^2}$

Step 2: Use the given ratios to relate the thermal resistances.
We are given $\frac{L_A}{L_B} = \frac{1}{2}$, $\frac{r_A}{r_B} = 2$, and $\frac{K_A}{K_B} = \frac{1}{2}$.
Consider the ratio of the thermal resistances:

$$\frac{R_{th,A}}{R_{th,B}} = \frac{\frac{L_A}{K_A \pi r_A^2}}{\frac{L_B}{K_B \pi r_B^2}} = \frac{L_A}{L_B} \cdot \frac{K_B}{K_A} \cdot \frac{\pi r_B^2}{\pi r_A^2} = \frac{L_A}{L_B} \cdot \frac{K_B}{K_A} \cdot \left(\frac{r_B}{r_A}\right)^2$$

Substitute the given ratios:

$$\frac{R_{th,A}}{R_{th,B}} = \left(\frac{1}{2}\right) \cdot \left(\frac{1}{1/2}\right) \cdot \left(\frac{1}{2}\right)^2 = \frac{1}{2} \cdot 2 \cdot \frac{1}{4} = \frac{1}{4}$$

So, $R_{th,A} = \frac{1}{4} R_{th,B}$, or $R_{th,B} = 4R_{th,A}$.

Step 3: Apply the concept of thermal current in series.
When the rods are joined in series, the rate of heat flow (thermal current I_{th}) through both rods is the same at equilibrium. Let the temperature of the interface be T. The thermal current through rod A is given by:

$$I_{th} = \frac{T_1 - T}{R_{th,A}} = \frac{400 - T}{R_{th,A}}$$

The thermal current through rod B is given by:

$$I_{th} = \frac{T - T_2}{R_{th,B}} = \frac{T - 200}{R_{th,B}}$$

Equating the thermal currents:

$$\frac{400 - T}{R_{th,A}} = \frac{T - 200}{R_{th,B}}$$

Substitute $R_{th,B} = 4R_{th,A}$:

$$\frac{400 - T}{R_{th,A}} = \frac{T - 200}{4R_{th,A}}$$

Multiply both sides by $4R_{th,A}$:

$$4(400 - T) = T - 200$$

$$1600 - 4T = T - 200$$

$$1600 + 200 = T + 4T$$

$$1800 = 5T$$

$$T = \frac{1800}{5} = 360\,K$$

The temperature of the rods interface is $360\,K$.

Quick Tip

Treat heat flow problems involving composite materials as analogous to electrical circuits. Thermal resistance plays the role of electrical resistance, temperature difference is analogous to voltage difference, and the rate of heat flow (thermal current) corresponds to electrical current. For rods in series, the thermal resistance is additive, and the thermal current is the same through each rod.

---

49. The electric field in a region is given by $\vec{E} = (2\hat{i} + 4\hat{j} + 6\hat{k}) \times 10^3\,N/C$. The flux of the field through a rectangular surface parallel to x-z plane is $6.0\,Nm^2C^{-1}$. The area of the surface is ____ cm^2.

Solution: Step 1: Understand the orientation of the surface.

The rectangular surface is parallel to the x-z plane. This means that the normal vector to the surface is along the y-axis (either $+\hat{j}$ or $-\hat{j}$). We can represent the area vector $\vec{A}$ as $\vec{A} = A\hat{j}$, where A is the area of the surface and $\hat{j}$ is the unit vector in the y-direction.

Step 2: Use the formula for electric flux.

The electric flux Φ through a surface is given by the dot product of the electric field $\vec{E}$ and the area vector $\vec{A}$:

$$\Phi = \vec{E} \cdot \vec{A}$$

Step 3: Substitute the given electric field and the area vector into the flux formula.

The electric field is $\vec{E} = (2\hat{i} + 4\hat{j} + 6\hat{k}) \times 10^3\,N/C$.

The area vector is $\vec{A} = A\hat{j}$.

The flux is given as $\Phi = 6.0\,Nm^2C^{-1}$.

$$6.0 = [(2\hat{i} + 4\hat{j} + 6\hat{k}) \times 10^3] \cdot (A\hat{j})$$

The dot product of the unit vectors is $\hat{i} \cdot \hat{j} = 0$, $\hat{j} \cdot \hat{j} = 1$, and $\hat{k} \cdot \hat{j} = 0$.

$$6.0 = (2 \times 10^3\hat{i} \cdot A\hat{j}) + (4 \times 10^3\hat{j} \cdot A\hat{j}) + (6 \times 10^3\hat{k} \cdot A\hat{j})$$

$$6.0 = 0 + (4 \times 10^3 \times A \times 1) + 0$$

$$6.0 = 4 \times 10^3 A$$

Step 4: Solve for the area A in m^2.

$$A = \frac{6.0}{4 \times 10^3}\, m^2$$

$$A = 1.5 \times 10^{-3}\, m^2$$

Step 5: Convert the area from m^2 to cm^2. We know that $1\,m = 100\,cm$, so $1\,m^2 = (100\,cm)^2 = 10000\,cm^2 = 10^4\,cm^2$.

$$A = 1.5 \times 10^{-3}\, m^2 \times \frac{10^4\, cm^2}{1\, m^2}$$

$$A = 1.5 \times 10^{-3+4}\, cm^2$$

$$A = 1.5 \times 10^{1}\, cm^2$$

$$A = 15\, cm^2$$

The area of the surface is $15\,cm^2$.

Quick Tip

The electric flux through a surface depends on the component of the electric field that is normal to the surface. When the surface is parallel to the x-z plane, its normal vector is along the y-axis, so only the y-component of the electric field contributes to the flux. Remember to convert units if the final answer requires a specific unit.

---

50. M and R be the mass and radius of a disc. A small disc of radius R/3 is removed from the bigger disc as shown in figure. The moment of inertia of remaining part of bigger disc about an axis AB passing through the centre O and perpendicular to the plane of disc is $\frac{4}{x}MR^2$. The value of x is ____.
Solution:

0.1 Given:

- Mass of original disc: M
- Radius of original disc: R
- Radius of removed disc: $R/3$
- Moment of inertia of remaining part: $\frac{4}{x}MR^2$

Step 1: Moment of Inertia of Original Disc
The moment of inertia of a solid disc about an axis through its center perpendicular to its plane is:

$$I_{\text{original}} = \frac{1}{2}MR^2$$

Step 2: Mass of Removed Disc
Assuming uniform mass distribution, the mass of the removed disc is proportional to its area:

$$m = \left(\frac{\pi(R/3)^2}{\pi R^2}\right) M = \frac{M}{9}$$

Step 3: Moment of Inertia of Removed Disc
Case 1: Concentric Removal
If the disc is removed concentrically:

$$I_{\text{removed}} = \frac{1}{2}m\left(\frac{R}{3}\right)^2 = \frac{1}{2}\left(\frac{M}{9}\right)\left(\frac{R^2}{9}\right) = \frac{MR^2}{162}$$

Case 2: Non-concentric Removal If the disc is removed tangentially (center at $2R/3$ from O), we must use the parallel axis theorem:

$$I_{\text{removed}} = \frac{1}{2}m\left(\frac{R}{3}\right)^2 + m\left(\frac{2R}{3}\right)^2 = \frac{MR^2}{162} + \frac{4MR^2}{81} = \frac{MR^2}{18}$$

Step 4: Moment of Inertia of Remaining Part
For Concentric Case:

$$I_{\text{remaining}} = I_{\text{original}} - I_{\text{removed}} = \frac{1}{2}MR^2 - \frac{MR^2}{162} = \frac{40}{81}MR^2$$

Given that $I_{\text{remaining}} = \frac{4}{x}MR^2$, we get:

$$\frac{40}{81} = \frac{4}{x} \implies x = \frac{81}{10}$$

For Non-concentric Case:

$$I_{\text{remaining}} = \frac{1}{2}MR^2 - \frac{MR^2}{18} = \frac{4}{9}MR^2$$

Given that $I_{\text{remaining}} = \frac{4}{x}MR^2$, we get:

$$\frac{4}{9} = \frac{4}{x} \implies x = 9$$

Conclusion Since the problem mentions "as shown in figure" but no figure is provided, the most reasonable assumption is that the disc is removed tangentially (non-concentrically), leading to:

$$x = \boxed{9}$$

Quick Tip

When a part of a uniform object is removed, the moment of inertia of the remaining part can be found by subtracting the moment of inertia of the removed part from the moment of inertia of the original object, ensuring both moments of inertia are calculated about the same axis. Remember to use the parallel axis theorem if the axes of the removed part and the remaining part are not the same.

CHEMISTRY

SECTION-A

51. Given below are two statements :
Statement (I) : On hydrolysis, oligo peptides give rise to fewer number of α-amino acids while proteins give rise to a large number of β-amino acids.
Statement (II) : Natural proteins are denatured by acids which convert the water soluble form of fibrous proteins to their water insoluble form.
In the light of the above statements, choose the most appropriate answer from the options given below :
(1) Both statement I and statement II are correct
(2) Statement I is incorrect but Statement II is correct
(3) Both statement I and statement II are incorrect
(4) Statement I is correct but Statement II is incorrect

---

52. Mixture of 1 g each of chlorobenzene, aniline and benzoic acid is dissolved in 50 mL ethyl acetate and placed in a separating funnel, 5 M NaOH (30 mL) was added in the same funnel. The funnel was shaken vigorously and then kept aside. The ethyl acetate layer in the funnel contains :
(1) benzoic acid
(2) benzoic acid and aniline
(3) benzoic acid and chlorobenzene
(4) chlorobenzene and aniline

---

53. The hydration energies of K^+ and Cl^- are $-x$ and $-y$ kJ/mol respectively. If lattice energy of KCl is $-z$ kJ/mol, then the heat of solution of KCl is :
(1) $+x - y - z$
(2) $x + y + z$
(3) $z - (x + y)$
(4) $-z - (x + y)$

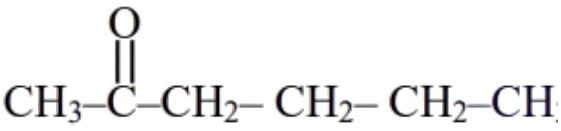
---

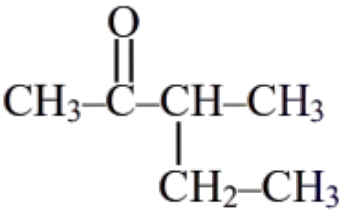
54. A(g) $\rightarrow$ B(g) + C(g) is a first order reaction.

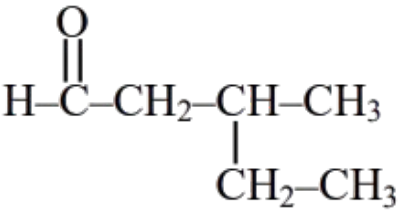
Time	T	∞
$\mathbf{P_{system}}$	P_t	P_∞

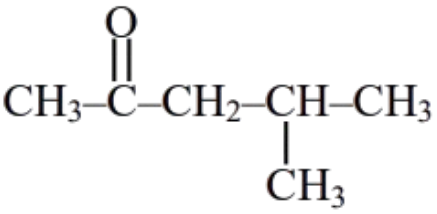
The reaction was started with reactant A only. Which of the following expression is correct for rate constant k ?
(1) $k = \frac{1}{t} \ln \frac{2(P_\infty - P_t)}{P_t}$
(2) $k = \frac{1}{t} \ln \frac{P_\infty}{P_t}$
(3) $k = \frac{1}{t} \ln \frac{P_\infty}{2(P_\infty - P_t)}$
(4) $k = \frac{1}{t} \ln \frac{P_\infty}{(P_\infty - P_t)}$

55. "P" is an optically active compound with molecular formula $C_6H_{12}O$. When "P" is treated with 2,4-dinitrophenylhydrazine, it gives a positive test. However, in presence of Tollens reagent, "P" gives a negative test. Predict the structure of "P".

(1) 

(2) 

(3) 

(4) 

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56. Choose the incorrect trend in the atomic radii (r) of the elements :

(1) $r_{Br} < r_K$

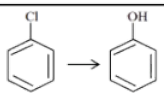
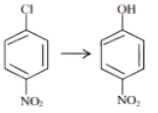
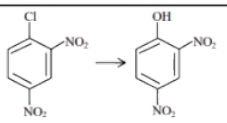
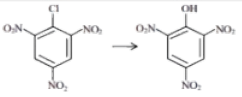
(2) $r_{Mg} < r_{Al}$

(3) $r_{Rb} < r_{Cs}$

(4) $r_{At} < r_{Cs}$

---

57. Match List-I with List-II

List-I Conversion		List-II Reagents, Conditions used	
(A)		(I)	Warm, H_2O
(B)		(II)	(a) NaOH, 368 K ; (b) H_3O^+
(C)		(III)	(a) NaOH, 443 K; (b) H_3O^+
(D)		(IV)	(a) NaOH, 623 K, 300 atm ; (b) H_3O^+

Choose the correct answer from the options given below :
(1) (A)-(II), (B)-(III), (C)-(I), (D)-(IV)
(2) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)
(3) (A)-(IV), (B)-(III), (C)-(II), (D)-(I)
(4) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)

---

58. The correct statement amongst the following is :
(1) The term 'standard state' implies that the temperature is $0°C$
(2) The standard state of pure gas is the pure gas at a pressure of 1 bar and temperature 273 K
(3) $\Delta_f H^{\ominus}_{298}$ is zero for O(g)
(4) $\Delta_f H^{\ominus}_{500}$ is zero for $O_2(g)$

---

59. Liquid A and B form an ideal solution. The vapour pressure of pure liquids A and B are 350 and 750 mm Hg respectively at the same temperature. If x_A and x_B are the mole fraction of A and B in solution while y_A and y_B are the mole fraction of A and B in vapour phase then :
(1) $\frac{x_A}{x_B} < \frac{y_A}{y_B}$
(2) $\frac{x_A}{x_B} = \frac{y_A}{y_B}$
(3) $\frac{x_A}{x_B} > \frac{y_A}{y_B}$
(4) $(x_A - y_A) < (x_B - y_B)$

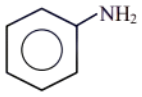
---

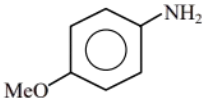
60. 'X' is the number of acidic oxides among $VO_2, V_2O_3, CrO_3, V_2O_5$ and Mn_2O_7. The primary valency of cobalt in $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$ is Y. The value of X + Y is :
(1) 5
(2) 4

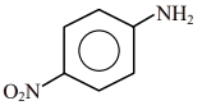
(3) 2
(4) 3

---

61. The descending order of basicity of following amines is :

(A) 

(B) 

(C) 

(D) CH_3NH_2

(E) $(CH_3)_2NH$

Choose the correct answer from the options given below :
(1) $B > E > D > A > C$
(2) $E > D > B > A > C$
(3) $E > D > A > B > C$
(4) $E > A > D > C > B$

---

62. Match List-I with List-II

List-I Complex		List-II Primary valency and Secondary valency	
(A)	$[Co(en)_2Cl_2]Cl$	(I)	3 6
(B)	$[Pt(NH_3)_2Cl(NO_2)]$	(II)	3 4
(C)	$Hg[Co(SCN)_4]$	(III)	2 6
(D)	$[Mg(EDTA)]^{2-}$	(IV)	2 4

Choose the correct answer from the options given below :
(1) (A)-(III), (B)-(I), (C)-(II), (D)-(IV)
(2) (A)-(I), (B)-(IV), (C)-(II), (D)-(III)
(3) (A)-(I), (B)-(III), (C)-(II), (D)-(IV)
(4) (A)-(II), (B)-(III), (C)-(IV), (D)-(I)

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63. Match List-I with List-II

List-I		List-II	
(A)	Solution of chloroform and acetone	(I)	Minimum boiling azeotrope
(B)	Solution of ethanol and water	(II)	Dimerizes
(C)	Solution of benzene and toluene	(III)	Maximum boiling azeotrope
(D)	Solution of acetic acid in benzene	(IV)	$\Delta V_{mix} = 0$

Choose the correct answer from the options given below :
(1) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)
(2) (A)-(II), (B)-(IV), (C)-(I), (D)-(III)
(3) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
(4) (A)-(II), (B)-(I), (C)-(IV), (D)-(III)

---

64. In SO_2, NO_2^- and N_3^- the hybridizations at the central atom are respectively :
(1) sp^2, sp^2 and sp
(2) sp^2, sp and sp
(3) sp^2, sp^2 and sp^2
(4) sp, sp^2 and sp

---

65. The number of unpaired electrons responsible for the paramagnetic nature of the following complex species are respectively : $[Fe(CN)_6]^{3-}, [FeF_6]^{3-}, [CoF_6]^{3-}, [Mn(CN)_6]^{3-}$
(1) 1, 5, 4, 2
(2) 1, 5, 5, 2
(3) 1, 1, 4, 2
(4) 1, 4, 4, 2

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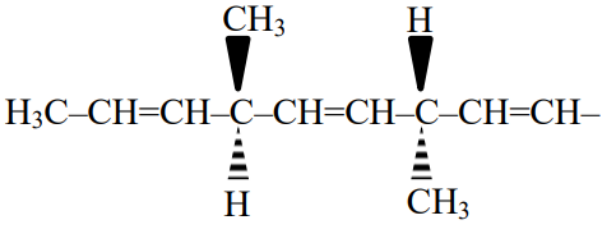
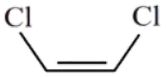
66. The number of optically active products obtained from the complete ozonolysis of the given compound is :

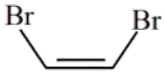


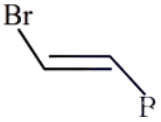
(1) 0
(2) 2
(3) 4
(4) 4

---

67. Given below are two statements :

Statement (I) :  is more polar than



Statement (II) : Boiling point of  .

lower than  but it is more polar than

In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Statement I is correct but statement II is incorrect
(2) Statement I is incorrect but statement II is correct
(3) Both statement I and statement II are incorrect
(4) Both statement I and statement II are correct

---

68. The extra stability of half-filled subshell is due to
(A) Symmetrical distribution of electrons
(B) Smaller coulombic repulsion energy
(C) The presence of electrons with the same spin in non-degenerate orbitals
(D) Larger exchange energy
(E) Relatively smaller shielding of electrons by one another
Identify the correct statements

(1) (B), (D) and (E) only
(2) (A), (B), (D) and (E) only
(3) (B), (C) and (D) only
(4) (A), (B) and (D) only

---

69. The correct statements from the following are :
(A) Tl^{3+} **is a powerful oxidising agent**
(B) Al^{3+} **does not get reduced easily**
(C) Both Al^{3+} **and** Tl^{3+} **are very stable in solution**
(D) Tl^{+} **is more stable than** Tl^{3+}
(E) Al^{3+} **and** Tl^{+} **are highly stable**
Choose the correct answer from the options given below :

(1) (A), (B), (C), (D) and (E)
(2) (A), (B), (D) and (E) only
(3) (B), (D) and (E) only
(4) (A), (C) and (D) only

---

70. Given below are two statements :
1 M aqueous solution of each of $Cu(NO_3)_2$, $AgNO_3$, $Hg_2(NO_3)_2$; $Mg(NO_3)_2$ are electrolysed using inert electrodes, Given : $E^0_{Ag^+/Ag} = 0.80V$, $E^0_{Hg_2^{2+}/Hg} = 0.79V$, $E^0_{Cu^{2+}/Cu} = 0.34V$ and $E^0_{Mg^{2+}/Mg} = -2.37V$
Statement (I) : With increasing voltage, the sequence of deposition of metals on the cathode will be Ag, Hg and Cu
Statement (II) : Magnesium will not be deposited at cathode instead oxygen gas will be evolved at the cathode.
In the light of the above statements, choose the most appropriate answer from the options given below :
(1) Both statement I and statement II are incorrect
(2) Statement I is correct but statement II is incorrect
(3) Both statement I and statement II are correct
(4) Statement I is incorrect but statement II is correct

SECTION-B

71. Only litre buffer solution was prepared by adding 0.10 mol each of NH_3 and NH_4Cl in deionised water. The change in pH on addition of 0.05 mol of HCl to the above solution is _____ $\times 10^{-2}$, (Nearest integer) (Given : pK_b of $NH_3 = 4.745$ and $\log_{10} 3 = 0.477$)

---

72. In Dumas' method 292 mg of an organic compound released 50 mL of nitrogen gas (N_2) at 300 K temperature and 715 mm Hg pressure. The percentage composition of 'N' in the organic compound is _____ % (Nearest integer) (Aqueous tension at 300 K = 15 mm Hg)

---

73. Butane reacts with oxygen to produce carbon dioxide and water following the equation given below:

$$C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

If 174.0 kg of butane is mixed with 320.0 kg of O_2, the volume of water formed in litres is _____. (Nearest integer)

[Given: (a) Molar masses: C = 12, H = 1, O = 16 g mol^{-1}; (b) Density of water = 1 g mL^{-1}]

74. The number of paramagnetic metal complex species among $[Co(NH_3)_6]^{3+}$, $[Co(C_2O_4)_3]^{3-}$, $[M$ and $[FeF_6]^{3-}$ with same number of unpaired electrons is _____.

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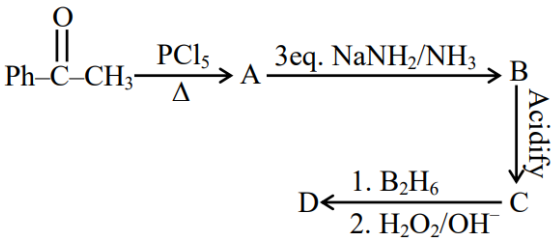
75. Identify the structure of the final product (D) in the following sequence of the reactions :



Total number of sp^2 hybridised carbon atoms in product D is _____.
