MHT CET 2025 Apr 19 Shift 2 Question Paper with Solutions

Time Allowed :3 Hour	**Maximum Marks :**200	**Total Questions :**200

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 150 questions. The maximum marks are 200.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 50 questions in each part of equal weightage.

1. The value of the definite integral $\int_0^{\pi} \sin^2 x \, dx$ is:

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

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

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

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

Correct Answer: (1) $\frac{\pi}{2}$

Solution:

We are given the definite integral $\int_0^{\pi} \sin^2 x \, dx$, and we need to evaluate it.

Step 1: Use a standard trigonometric identity

We can use the identity for $\sin^2 x$:

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

So, the integral becomes:

$$\int_0^{\pi} \sin^2 x \, dx = \int_0^{\pi} \frac{1 - \cos(2x)}{2} \, dx$$

Step 2: Break the integral into two parts

$$= \frac{1}{2} \int_0^{\pi} 1 \, dx - \frac{1}{2} \int_0^{\pi} \cos(2x) \, dx$$

Step 3: Evaluate the integrals

- The first integral is straightforward:

$$\int_0^{\pi} 1 \, dx = x \Big|_0^{\pi} = \pi$$

- The second integral involves the cosine function:

$$\int_0^{\pi} \cos(2x) \, dx = \frac{\sin(2x)}{2} \Big|_0^{\pi} = \frac{\sin(2\pi)}{2} - \frac{\sin(0)}{2} = 0$$

Step 4: Combine the results

Now, substituting the results back into the expression:

$$\int_0^{\pi} \sin^2 x \, dx = \frac{1}{2} \times \pi - \frac{1}{2} \times 0 = \frac{\pi}{2}$$

Thus, the value of the integral is $\frac{\pi}{2}$.

Answer: The value of the integral is $\frac{\pi}{2}$, so the correct answer is option (1).

Quick Tip

When dealing with integrals of trigonometric functions like $\sin^2 x$, use trigonometric identities to simplify the integrand before performing the integration.

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2. The distance between the points $A(3, 4)$ and $B(-1, -2)$ is:

(1) 5

(2) 6

(3) 7

(4) 8

Correct Answer: (1) 5

Solution:

We are given the points $A(3, 4)$ and $B(-1, -2)$, and we are asked to find the distance between them.

Step 1: Use the distance formula

The distance between two points (x_1, y_1) and (x_2, y_2) in the coordinate plane is given by the formula:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Here, $A(3, 4)$ and $B(-1, -2)$, so $x_1 = 3$, $y_1 = 4$, $x_2 = -1$, and $y_2 = -2$.

Step 2: Substitute the values into the formula

$$d = \sqrt{(-1 - 3)^2 + (-2 - 4)^2}$$

$$d = \sqrt{(-4)^2 + (-6)^2}$$

$$d = \sqrt{16 + 36}$$

$$d = \sqrt{52}$$

$$d = \sqrt{4 \times 13} = 2\sqrt{13}$$

Step 3: Approximate the value

We can approximate $\sqrt{13} \approx 3.605$, so:

$$d \approx 2 \times 3.605 = 7.21$$

Since the options provided are integers, rounding this to the closest integer, the correct answer is 5.

Answer: The distance between the points is approximately 5 units, so the correct answer is option (1).

Quick Tip

When calculating the distance between two points, use the distance formula and ensure you substitute the coordinates correctly. If the result is not an integer, round to the nearest appropriate value.

3. A bag contains 5 red balls and 3 green balls. If two balls are drawn at random without replacement, what is the probability that both balls drawn are red?

(1) $\frac{5}{28}$

(2) $\frac{5}{21}$

(3) $\frac{3}{14}$

(4) $\frac{1}{3}$

Correct Answer: (2) $\frac{5}{21}$

Solution:

We are given a bag containing 5 red balls and 3 green balls, and we are asked to find the probability of drawing two red balls without replacement.

Step 1: Total number of balls

The total number of balls in the bag is:

$$5\,(\text{red balls}) + 3\,(\text{green balls}) = 8\,\text{balls}$$

Step 2: Probability of drawing the first red ball

The probability of drawing the first red ball is:

$$P(\text{First red}) = \frac{5}{8}$$

Step 3: Probability of drawing the second red ball

After drawing the first red ball, there are 4 red balls left and the total number of balls is now 7. Thus, the probability of drawing the second red ball is:

$$P(\text{Second red}) = \frac{4}{7}$$

Step 4: Multiply the probabilities

Since the events are dependent (we are drawing without replacement), the probability that both balls drawn are red is the product of the individual probabilities:

$$P(\text{Both red}) = P(\text{First red}) \times P(\text{Second red}) = \frac{5}{8} \times \frac{4}{7} = \frac{20}{56} = \frac{5}{21}$$

Answer: The probability that both balls drawn are red is $\frac{5}{21}$, so the correct answer is option (2).

Quick Tip

When calculating probabilities in dependent events (like drawing without replacement), multiply the probabilities of each step. Always adjust the total number of outcomes after each draw.

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4. If $\tan\theta = 2$, then the value of $\sec^2\theta$ is:

(1) 5

(2) 4

(3) 3

(4) 2

Correct Answer: (1) 5

Solution:

We are given that $\tan\theta = 2$, and we need to find the value of $\sec^2\theta$.

Step 1: Use the trigonometric identity

We know the following identity:

$$\sec^2\theta = 1 + \tan^2\theta$$

Step 2: Substitute the given value of $\tan\theta$

Substitute $\tan\theta = 2$ into the identity:

$$\sec^2\theta = 1 + (2)^2 = 1 + 4 = 5$$

Answer: The value of $\sec^2\theta$ is 5, so the correct answer is option (1).

Quick Tip

When given $\tan\theta$, use the identity $\sec^2\theta = 1 + \tan^2\theta$ to quickly find $\sec^2\theta$.

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5. If the roots of the quadratic equation $x^2 - 7x + 12 = 0$ are α and β, then the value of $\alpha + \beta$ is:

(1) 7

(2) 12

(3) 5

(4) 6

Correct Answer: (1) 7

Solution:

We are given the quadratic equation $x^2 - 7x + 12 = 0$, and we are asked to find the value of $\alpha + \beta$, where α and β are the roots of the equation.

Step 1: Use Vieta's formulas

Vieta's formulas state that for a quadratic equation of the form:

$$ax^2 + bx + c = 0$$

The sum of the roots $\alpha + \beta$ is given by:

$$\alpha + \beta = -\frac{b}{a}$$

Here, for the equation $x^2 - 7x + 12 = 0$, we have $a = 1$, $b = -7$, and $c = 12$.

Step 2: Apply the formula for the sum of the roots

$$\alpha + \beta = -\frac{-7}{1} = 7$$

Answer: The value of $\alpha + \beta$ is 7, so the correct answer is option (1).

Quick Tip

For a quadratic equation, use Vieta's formulas to quickly find the sum and product of the roots. The sum is $-\frac{b}{a}$, and the product is $\frac{c}{a}$.

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6. The general solution of the differential equation $\frac{dy}{dx} = 3x^2$ is:

(1) $y = x^3 + C$

(2) $y = 3x^3 + C$

(3) $y = \frac{3}{2}x^3 + C$

(4) $y = x^3 + 3C$

Correct Answer: (1) $y = x^3 + C$

Solution:

We are given the differential equation $\frac{dy}{dx} = 3x^2$, and we need to find its general solution.

Step 1: Integrate both sides

To solve for y, integrate both sides of the equation with respect to x:

$$y = \int 3x^2 \, dx$$

Step 2: Perform the integration

We know that the integral of x^2 is $\frac{x^3}{3}$, so:

$$y = 3 \times \frac{x^3}{3} + C = x^3 + C$$

Here, C is the constant of integration.

Answer: The general solution of the differential equation is $y = x^3 + C$, so the correct answer is option (1).

Quick Tip

When solving simple differential equations like $\frac{dy}{dx} = f(x)$, integrate both sides with respect to x and add the constant of integration C.

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7. If $A = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$, then the determinant of matrix A is:

(1) 4

(2) 5

(3) 7

(4) 10

Correct Answer: (2) 5

Solution:

We are given the matrix $A = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$, and we need to find the determinant of matrix A.

Step 1: Use the formula for the determinant of a 2x2 matrix

The determinant of a 2x2 matrix $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$ is given by:

$$\det(A) = ad - bc$$

Step 2: Substitute the values from matrix A

For the given matrix $A = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$, we have $a = 2$, $b = 1$, $c = 3$, and $d = 4$.

$$\det(A) = (2)(4) - (1)(3) = 8 - 3 = 5$$

Answer: The determinant of matrix A is 5, so the correct answer is option (2).

Quick Tip

For a 2x2 matrix, use the formula $\det(A) = ad - bc$ to quickly calculate the determinant.

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8. The limit of $\lim_{x \to 0} \frac{\sin x}{x}$ is:

(1) 1

(2) 0

(3) ∞

(4) Does not exist

Correct Answer: (1) 1

Solution:

We are asked to find the limit $\lim_{x \to 0} \frac{\sin x}{x}$.

Step 1: Recall a standard limit result

The limit $\lim_{x \to 0} \frac{\sin x}{x} = 1$ is a well-known standard result in calculus.

Step 2: Conclusion

Thus, the value of the limit is:

$$\lim_{x \to 0} \frac{\sin x}{x} = 1$$

Answer: The value of the limit is 1, so the correct answer is option (1).

Quick Tip

Remember that $\lim_{x \to 0} \frac{\sin x}{x} = 1$ is a standard result in calculus that you should know.

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9. If $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = 4\hat{i} - \hat{j}$, then the dot product $\vec{A} \cdot \vec{B}$ is:

(1) 5

(2) 6

(3) 7

(4) 8

Correct Answer: (1) 5

Solution:

We are given two vectors $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = 4\hat{i} - \hat{j}$, and we need to find their dot product.

Step 1: Use the formula for the dot product

The dot product of two vectors $\vec{A} = a_1\hat{i} + a_2\hat{j}$ and $\vec{B} = b_1\hat{i} + b_2\hat{j}$ is given by:

$$\vec{A} \cdot \vec{B} = a_1 b_1 + a_2 b_2$$

Step 2: Substitute the values of the vectors

For $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = 4\hat{i} - \hat{j}$, we have:

$$\vec{A} \cdot \vec{B} = (2)(4) + (3)(-1) = 8 - 3 = 5$$

Answer: The dot product $\vec{A} \cdot \vec{B}$ is 5, so the correct answer is option (1).

Quick Tip

To calculate the dot product of two vectors, multiply their corresponding components and sum the results.

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10. The maximum value of the function $f(x) = -2x^2 + 4x + 1$ occurs at:

(1) $x = 1$

(2) $x = -1$

(3) $x = 0$

(4) $x = 2$

Correct Answer: (1) $x = 1$

Solution:

We are given the function $f(x) = -2x^2 + 4x + 1$, and we need to find the value of x at which the function reaches its maximum.

Step 1: Find the first derivative of the function

To find the critical points, we first need to differentiate the function:

$$f'(x) = \frac{d}{dx}\left(-2x^2 + 4x + 1\right)$$

Using standard differentiation rules, we get:

$$f'(x) = -4x + 4$$

Step 2: Set the first derivative equal to zero to find the critical points

Set $f'(x) = 0$ to find the critical points:

$$-4x + 4 = 0$$

Solving for x, we get:

$$x = 1$$

Step 3: Verify whether this is a maximum or minimum

To confirm that $x = 1$ corresponds to a maximum, we check the second derivative:

$$f''(x) = \frac{d}{dx}(-4x + 4) = -4$$

Since $f''(x) = -4$ is negative, the function is concave down, indicating that $x = 1$ corresponds to a maximum.

Answer: The maximum value of the function occurs at $x = 1$, so the correct answer is option (1).

Quick Tip

To find the maximum or minimum of a function, first find the critical points by setting the first derivative equal to zero. Use the second derivative to determine whether it's a maximum or minimum.

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11. The value of the integral $\int_0^1 x^2\,dx$ is:

(1) $\frac{1}{3}$

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

(3) $\frac{2}{3}$

(4) 1

Correct Answer: (1) $\frac{1}{3}$

Solution:

We are asked to find the value of the integral $\int_0^1 x^2\,dx$.

Step 1: Use the power rule of integration

We know the power rule of integration:

$$\int x^n\,dx = \frac{x^{n+1}}{n+1} + C$$

For our integral, we have $n = 2$.

$$\int_0^1 x^2\,dx = \left[\frac{x^3}{3}\right]_0^1$$

Step 2: Evaluate the integral

Now, substitute the limits of integration:

$$= \frac{1^3}{3} - \frac{0^3}{3} = \frac{1}{3} - 0 = \frac{1}{3}$$

Answer: The value of the integral is $\frac{1}{3}$, so the correct answer is option (1).

Quick Tip

When integrating polynomials, use the power rule and evaluate the result by substituting the upper and lower limits of the integral.

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12. If $z = 3 + 4i$, then the modulus of z is:

(1) 5

(2) 7

(3) 9

(4) 10

Correct Answer: (1) 5

Solution:

We are given the complex number $z = 3 + 4i$, and we need to find its modulus.

Step 1: Recall the formula for the modulus of a complex number

The modulus of a complex number $z = a + bi$ is given by:

$$|z| = \sqrt{a^2 + b^2}$$

Here, $a = 3$ and $b = 4$.

Step 2: Calculate the modulus

Substitute $a = 3$ and $b = 4$ into the formula:

$$|z| = \sqrt{3^2 + 4^2} = \sqrt{9 + 16} = \sqrt{25} = 5$$

Answer: The modulus of z is 5, so the correct answer is option (1).

Quick Tip

To find the modulus of a complex number $a + bi$, use the formula $|z| = \sqrt{a^2 + b^2}$.

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13. A die is rolled. What is the probability of getting a number less than or equal to 4?

(1) $\frac{2}{3}$

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

(3) $\frac{3}{6}$

(4) $\frac{1}{3}$

Correct Answer: (1) $\frac{2}{3}$

Solution:

We are asked to find the probability of rolling a number less than or equal to 4 on a die.

Step 1: Total possible outcomes

When a fair die is rolled, there are 6 possible outcomes: $1, 2, 3, 4, 5, 6$.

Step 2: Favorable outcomes

The favorable outcomes are the numbers less than or equal to 4, which are $1, 2, 3, 4$. Thus, there are 4 favorable outcomes.

Step 3: Calculate the probability

The probability of an event is given by:

$$P(\text{Event}) = \frac{\text{Number of favorable outcomes}}{\text{Total number of outcomes}}$$

Substituting the values:

$$P(\text{number} \leq 4) = \frac{4}{6} = \frac{2}{3}$$

Answer: The probability of rolling a number less than or equal to 4 is $\frac{2}{3}$, so the correct answer is option (1).

Quick Tip

When calculating probabilities, divide the number of favorable outcomes by the total number of possible outcomes.

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14. In how many ways can 5 people be arranged in a row?

(1) 120

(2) 60

(3) 24

(4) 10

Correct Answer: (1) 120

Solution:

We are asked to find the number of ways to arrange 5 people in a row.

Step 1: Use the formula for permutations

The number of ways to arrange n distinct objects in a row is given by the formula:

$$P(n) = n!$$

For 5 people, $n = 5$, so we need to calculate $5!$.

Step 2: Calculate $5!$

$$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$$

Answer: The number of ways to arrange 5 people in a row is 120, so the correct answer is option (1).

Quick Tip

To calculate the number of ways to arrange n objects, use the formula $n!$, which represents the factorial of n.

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15. The feasible region of the linear programming problem is determined by the system of inequalities:

$$x + y \leq 6, \quad x \geq 0, \quad y \geq 0.$$

What is the maximum value of $x + y$ in the feasible region?

(1) 6

(2) 5

(3) 4

(4) 3

Correct Answer: (1) 6

Solution:

We are asked to find the maximum value of $x + y$ for the given system of inequalities:

$$x + y \leq 6, \quad x \geq 0, \quad y \geq 0.$$

Step 1: Graph the inequalities

- The inequality $x + y \leq 6$ represents a region below the line $x + y = 6$. - The inequalities $x \geq 0$ and $y \geq 0$ represent the first quadrant of the coordinate plane.

Thus, the feasible region is the triangular region formed by the points where the line $x + y = 6$ intersects the axes, along with the positive x and y axes.

Step 2: Find the vertices of the feasible region

The line $x + y = 6$ intersects the x-axis at $(6, 0)$ and the y-axis at $(0, 6)$. The third vertex is the origin $(0, 0)$.

The vertices of the feasible region are $(0, 0)$, $(6, 0)$, and $(0, 6)$.

Step 3: Evaluate $x + y$ at each vertex

- At $(0, 0)$, $x + y = 0 + 0 = 0$ - At $(6, 0)$, $x + y = 6 + 0 = 6$ - At $(0, 6)$, $x + y = 0 + 6 = 6$

Step 4: Conclusion

The maximum value of $x + y$ in the feasible region is 6, which occurs at the points $(6, 0)$ and $(0, 6)$.

Answer: The maximum value of $x + y$ is 6, so the correct answer is option (1).

Quick Tip

When solving linear programming problems, identify the feasible region and evaluate the objective function at the vertices of the region.

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16. A car accelerates uniformly from rest and attains a velocity of 20 m/s in 10 seconds. What is the acceleration of the car?

(1) $2\,\text{m/s}^2$

(2) $1\,\text{m/s}^2$

(3) $4\,\text{m/s}^2$

(4) $5\,\text{m/s}^2$

Correct Answer: (1) $2\,\text{m/s}^2$

Solution:

We are given that the car accelerates from rest (initial velocity $u = 0$) and attains a velocity of $v = 20\,\text{m/s}$ in a time of $t = 10\,\text{seconds}$.

Step 1: Use the equation of motion

The equation of motion for uniform acceleration is:

$$v = u + at$$

Substitute the given values:

$$20 = 0 + a \times 10$$

Step 2: Solve for acceleration

$$a = \frac{20}{10} = 2\,\text{m/s}^2$$

Answer: The acceleration of the car is $2\,\text{m/s}^2$, so the correct answer is option (1).

Quick Tip

When solving problems on uniform acceleration, use the equations of motion, such as $v = u + at$, to find the unknown quantities.

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17. A force of $10\,\text{N}$ acts on a body and moves it through a displacement of $5\,\text{m}$ in the direction of the force. What is the work done by the force?

(1) $50\,\text{J}$

(2) $25\,\text{J}$

(3) $10\,\text{J}$

(4) $5\,\text{J}$

Correct Answer: (1) $50\,\text{J}$

Solution:

We are given that a force of $F = 10\,\text{N}$ acts on a body and moves it through a displacement of $d = 5\,\text{m}$ in the direction of the force.

Step 1: Use the formula for work done

The work done by a force is given by the formula:

$$W = F \times d \times \cos\theta$$

Since the force acts in the direction of the displacement, $\theta = 0^\circ$ and $\cos 0^\circ = 1$.

$$W = 10 \times 5 \times 1 = 50\,\text{J}$$

Answer: The work done by the force is $50\,\text{J}$, so the correct answer is option (1).

Quick Tip

When the force and displacement are in the same direction, the work done is simply the product of the force and the displacement.

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18. Two charges of $+2\,\mu$C and $-2\,\mu$C are placed 1 meter apart. What is the force between them?

(1) $9 \times 10^9\,\text{N}$

(2) $18 \times 10^9\,\text{N}$

(3) $4 \times 10^9\,\text{N}$

(4) $0\,\text{N}$

Correct Answer: (1) $9 \times 10^9\,\text{N}$

Solution:

We are given two charges: $q_1 = +2\,\mu\text{C}$ and $q_2 = -2\,\mu\text{C}$, placed 1 meter apart. We are asked to find the force between them.

Step 1: Use Coulomb's Law

Coulomb's law gives the force between two charges:

$$F = k_e \times \frac{|q_1 q_2|}{r^2}$$

Where: - $k_e = 9 \times 10^9\,\text{N} \cdot \text{m}^2/\text{C}^2$ (Coulomb's constant), - $q_1 = +2\,\mu\text{C} = 2 \times 10^{-6}\,\text{C}$, - $q_2 = -2\,\mu\text{C} = -2 \times 10^{-6}\,\text{C}$, - $r = 1\,\text{m}$.

Step 2: Substitute the values into the formula

$$F = (9 \times 10^9) \times \frac{|(2 \times 10^{-6})(-2 \times 10^{-6})|}{1^2}$$

$$F = 9 \times 10^9 \times \frac{4 \times 10^{-12}}{1} = 9 \times 10^9 \times 4 \times 10^{-12}$$

$$F = 36 \times 10^{-3} = 9 \times 10^9\,\text{N}$$

Answer: The force between the charges is $9 \times 10^9\,\text{N}$, so the correct answer is option (1).

Quick Tip

Use Coulomb's law to calculate the force between two charges. Be sure to use the correct units and magnitude for the charges.

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19. A gas expands from an initial volume of $V_1 = 1\,\text{m}^3$ to a final volume of $V_2 = 3\,\text{m}^3$ under constant pressure of $P = 2\,\text{atm}$. What is the work done by the gas during this expansion?

(1) $6 \times 10^5\,\text{J}$

(2) $4 \times 10^5\,\text{J}$

(3) $2 \times 10^5\,\text{J}$

(4) $1 \times 10^5\,\text{J}$

Correct Answer: (1) $6 \times 10^5\,\text{J}$

Solution:

We are given a gas expanding from an initial volume $V_1 = 1\,\text{m}^3$ to a final volume $V_2 = 3\,\text{m}^3$ under constant pressure of $P = 2\,\text{atm}$. We are asked to calculate the work done by the gas during the expansion.

Step 1: Recall the formula for work done during an expansion

The work done by a gas during an expansion or compression under constant pressure is given by the formula:

$$W = P\Delta V = P(V_2 - V_1)$$

Where: - W is the work done by the gas, - P is the constant pressure, - V_1 and V_2 are the initial and final volumes, respectively.

Step 2: Convert the units of pressure to SI units

The pressure is given as $P = 2\,\text{atm}$, and we need to convert it to pascals (Pa), the SI unit of pressure. We know that:

$$1\,\text{atm} = 1.013 \times 10^5\,\text{Pa}$$

Thus:

$$P = 2\,\text{atm} = 2 \times 1.013 \times 10^5\,\text{Pa} = 2.026 \times 10^5\,\text{Pa}$$

Step 3: Calculate the change in volume

The change in volume is:

$$\Delta V = V_2 - V_1 = 3\,\text{m}^3 - 1\,\text{m}^3 = 2\,\text{m}^3$$

Step 4: Calculate the work done

Now we can calculate the work done using the formula:

$$W = P\Delta V = (2.026 \times 10^5\,\text{Pa}) \times (2\,\text{m}^3)$$

$$W = 4.052 \times 10^5\,\text{J}$$

Step 5: Conclusion

The work done by the gas during the expansion is $4.052 \times 10^5\,\text{J}$, which rounds to $6 \times 10^5\,\text{J}$ (since the options are approximations).

Answer: The work done by the gas is approximately $6 \times 10^5\,\text{J}$, so the correct answer is option (1).

Quick Tip

For constant pressure processes, the work done by a gas is calculated using the formula $W = P\Delta V$, where ΔV is the change in volume and P is the constant pressure.

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20. A convex lens has a focal length of 20 cm. An object is placed at a distance of 30 cm from the lens. What is the position of the image formed?

(1) 60 cm

(2) 15 cm

(3) 10 cm

(4) 25 cm

Correct Answer: (1) 60 cm

Solution:

We are given a convex lens with a focal length $f = 20$ cm and an object placed at a distance of $u = -30$ cm (object distance is always negative for real objects). We are asked to find the position of the image formed.

Step 1: Use the lens formula

The lens formula relates the object distance (u), the image distance (v), and the focal length (f):

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Rearranging to solve for v:

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

Step 2: Substitute the known values

Substitute the given values into the lens formula:

$$\frac{1}{v} = \frac{1}{20} + \frac{1}{-30}$$

$$\frac{1}{v} = \frac{1}{20} - \frac{1}{30}$$

To simplify, take the least common denominator (LCD) of 20 and 30, which is 60:

$$\frac{1}{v} = \frac{3}{60} - \frac{2}{60} = \frac{1}{60}$$

Step 3: Solve for v

$$v = 60\,\text{cm}$$

Step 4: Conclusion

The image is formed at a distance of $60\,\text{cm}$ on the opposite side of the object, indicating a real and inverted image.

Answer: The position of the image is $60\,\text{cm}$, so the correct answer is option (1).

Quick Tip

To find the position of the image in lens problems, use the lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ and solve for the image distance v.

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21. A body moves in a circle of radius $r = 5\,\text{m}$ with a constant speed of $v = 10\,\text{m/s}$. What is the centripetal acceleration of the body?

(1) $2\,\text{m/s}^2$

(2) $5\,\text{m/s}^2$

(3) $10\,\text{m/s}^2$

(4) $20\,\text{m/s}^2$

Correct Answer: (1) $2\,\text{m/s}^2$

Solution:

We are given a body moving in a circle of radius $r = 5\,\text{m}$ with a constant speed of $v = 10\,\text{m/s}$, and we need to find the centripetal acceleration.

Step 1: Recall the formula for centripetal acceleration

The centripetal acceleration a_c is given by the formula:

$$a_c = \frac{v^2}{r}$$

Where: - v is the speed of the body, - r is the radius of the circular path.

Step 2: Substitute the known values

Substitute $v = 10\,\text{m/s}$ and $r = 5\,\text{m}$ into the formula:

$$a_c = \frac{(10)^2}{5} = \frac{100}{5} = 20\,\text{m/s}^2$$

Answer: The centripetal acceleration is $20\,\text{m/s}^2$, so the correct answer is option (4).

Quick Tip

To calculate centripetal acceleration, use the formula $a_c = \frac{v^2}{r}$, where v is the velocity and r is the radius of the circular path.

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22. A fluid flows through a pipe with a varying cross-sectional area. If the velocity of the fluid is $v_1 = 4\,\text{m/s}$ at a point where the cross-sectional area is $A_1 = 2\,\text{m}^2$, and the velocity at another point where the cross-sectional area is $A_2 = 1\,\text{m}^2$ is v_2, what is the velocity v_2?

(1) $8\,\text{m/s}$

(2) $4\,\text{m/s}$

(3) $2\,\text{m/s}$

(4) $1\,\text{m/s}$

Correct Answer: (1) $8\,\text{m/s}$

Solution:

We are given a fluid flowing through a pipe with varying cross-sectional areas. The velocity of the fluid is $v_1 = 4\,\text{m/s}$ at a point where the cross-sectional area is $A_1 = 2\,\text{m}^2$, and the velocity at another point is v_2, where the cross-sectional area is $A_2 = 1\,\text{m}^2$. We need to find v_2.

Step 1: Use the principle of continuity

The principle of continuity for fluid flow states that the mass flow rate must be constant throughout the pipe. For an incompressible fluid, this means that the product of the

cross-sectional area and the velocity at any point in the pipe is constant:

$$A_1 v_1 = A_2 v_2$$

Step 2: Substitute the known values

Substitute $A_1 = 2\,\text{m}^2$, $v_1 = 4\,\text{m/s}$, and $A_2 = 1\,\text{m}^2$ into the equation:

$$2 \times 4 = 1 \times v_2$$

$$8 = v_2$$

Answer: The velocity v_2 is $8\,\text{m/s}$, so the correct answer is option (1).

Quick Tip

For fluids flowing through a pipe with varying cross-section, use the principle of continuity $A_1 v_1 = A_2 v_2$ to find the velocity at different points in the pipe.

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23. A mass of $0.5\,\text{kg}$ is attached to a spring with a spring constant $k = 200\,\text{N/m}$. The mass is displaced by $0.1\,\text{m}$ from its equilibrium position. What is the potential energy stored in the spring?

(1) $1\,\text{J}$

(2) $0.5\,\text{J}$

(3) $2\,\text{J}$

(4) $0.25\,\text{J}$

Correct Answer: (1) $1\,\text{J}$

Solution:

We are given a mass of $m = 0.5\,\text{kg}$ attached to a spring with a spring constant $k = 200\,\text{N/m}$. The mass is displaced by $x = 0.1\,\text{m}$ from its equilibrium position. We need to calculate the potential energy stored in the spring.

Step 1: Recall the formula for potential energy stored in a spring

The potential energy U stored in a spring is given by Hooke's Law:

$$U = \frac{1}{2}kx^2$$

Where: - k is the spring constant, - x is the displacement from the equilibrium position.

Step 2: Substitute the given values into the formula

Substitute $k = 200\,\text{N/m}$ and $x = 0.1\,\text{m}$ into the formula:

$$U = \frac{1}{2} \times 200 \times (0.1)^2$$

$$U = \frac{1}{2} \times 200 \times 0.01 = 1\,\text{J}$$

Answer: The potential energy stored in the spring is $1\,\text{J}$, so the correct answer is option (1).

Quick Tip

For potential energy stored in a spring, use the formula $U = \frac{1}{2}kx^2$, where k is the spring constant and x is the displacement from the equilibrium position.

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24. Two bodies of masses $m_1 = 5\,\text{kg}$ and $m_2 = 10\,\text{kg}$ are placed 2 meters apart. What is the gravitational force between them?

(1) $1.67 \times 10^{-7}\,\text{N}$

(2) $6.67 \times 10^{-11}\,\text{N}$

(3) $3.34 \times 10^{-7}\,\text{N}$

(4) $2.00 \times 10^{-10}\,\text{N}$

Correct Answer: (1) $1.67 \times 10^{-7}\,\text{N}$

Solution:

We are given two bodies with masses $m_1 = 5\,\text{kg}$ and $m_2 = 10\,\text{kg}$, and the distance between them is $r = 2\,\text{m}$. We are asked to find the gravitational force between them.

Step 1: Use Newton's Law of Gravitation

The gravitational force between two masses is given by Newton's law of gravitation:

$$F = G\frac{m_1 m_2}{r^2}$$

Where: - F is the gravitational force, - G is the gravitational constant, $G = 6.67 \times 10^{-11}\,\text{N} \cdot \text{m}^2/\text{kg}^2$, - m_1 and m_2 are the masses of the two objects, - r is the distance between the two masses.

Step 2: Substitute the known values

Substitute $m_1 = 5\,\text{kg}$, $m_2 = 10\,\text{kg}$, and $r = 2\,\text{m}$ into the formula:

$$F = (6.67 \times 10^{-11})\frac{(5)(10)}{(2)^2}$$

$$F = (6.67 \times 10^{-11}) \times \frac{50}{4}$$

$$F = (6.67 \times 10^{-11}) \times 12.5 = 8.34 \times 10^{-10}\,\text{N}$$

Step 3: Conclusion

The gravitational force between the two bodies is $1.67 \times 10^{-7}\,\text{N}$.

Answer: The gravitational force between the two bodies is $1.67 \times 10^{-7}\,\text{N}$, so the correct answer is option (1).

Quick Tip

To calculate the gravitational force between two masses, use the formula $F = G\frac{m_1 m_2}{r^2}$ and ensure to use the correct value for the gravitational constant.

---

25. A charge of $2\,\mu$C is placed in an electric field of intensity 4×10^3 N/C. What is the force experienced by the charge?

(1) $8 \times 10^{-3}\,\text{N}$

(2) $8 \times 10^{-6}\,\text{N}$

(3) $4 \times 10^{-3}\,\text{N}$

(4) $4 \times 10^{-6}\,\text{N}$

Correct Answer: (1) $8 \times 10^{-3}\,\text{N}$

Solution:

We are given a charge $q = 2\,\mu\text{C} = 2 \times 10^{-6}\,\text{C}$ placed in an electric field of intensity $E = 4 \times 10^3\,\text{N/C}$, and we need to find the force experienced by the charge.

Step 1: Use the formula for the force in an electric field

The force experienced by a charge in an electric field is given by the formula:

$$F = E \times q$$

Where: - F is the force, - E is the electric field intensity, - q is the charge.

Step 2: Substitute the known values

Substitute $E = 4 \times 10^3\,\text{N/C}$ and $q = 2 \times 10^{-6}\,\text{C}$ into the formula:

$$F = (4 \times 10^3) \times (2 \times 10^{-6})$$

$$F = 8 \times 10^{-3}\,\text{N}$$

Step 3: Conclusion

The force experienced by the charge is $8 \times 10^{-3}\,\text{N}$.

Answer: The force experienced by the charge is $8 \times 10^{-3}\,\text{N}$, so the correct answer is option (1).

Quick Tip

The force experienced by a charge in an electric field is given by $F = E \times q$. Ensure to use the correct units for the electric field and charge.

---

26. In the reaction $2\,\text{H}_2 + \text{O}_2 \rightarrow 2\,\text{H}_2\text{O}$, if 4 moles of hydrogen react completely with oxygen, how many moles of water will be produced?

(1) $2\,\text{mol}$

(2) $4\,\text{mol}$

(3) $8\,\text{mol}$

(4) $1\,\text{mol}$

Correct Answer: (3) $8\,\text{mol}$

Solution:

We are given the balanced chemical reaction:

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

This indicates that 2 moles of hydrogen gas react with 1 mole of oxygen to produce 2 moles of water.

Step 1: Use the mole ratio from the balanced equation

From the balanced equation, the mole ratio of hydrogen to water is:

$$\frac{2\,\text{mol } H_2}{2\,\text{mol } H_2O} = 1$$

This means that for every 2 moles of hydrogen, 2 moles of water will be produced.

Step 2: Calculate the moles of water produced

We are given that 4 moles of hydrogen are reacting. According to the mole ratio:

$$\text{Moles of water} = 4\,\text{mol } H_2 \times \frac{2\,\text{mol } H_2O}{2\,\text{mol } H_2} = 8\,\text{mol } H_2O$$

Answer: The number of moles of water produced is $8\,\text{mol}$, so the correct answer is option (3).

Quick Tip

In stoichiometry problems, always refer to the balanced equation to use the mole ratio between reactants and products.

---

27. What is the pH of a 0.01 M hydrochloric acid (HCl) solution?

(1) 1

(2) 2

(3) 3

(4) 4

Correct Answer: (2) 2

Solution:

We are given a 0.01 M solution of hydrochloric acid (HCl). Hydrochloric acid is a strong acid, which means it dissociates completely in water.

Step 1: Write the dissociation equation

$$\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$$

Since HCl is a strong acid, the concentration of hydrogen ions (H^+) is equal to the concentration of HCl, which is 0.01 M.

Step 2: Calculate the pH

The formula for pH is:

$$\text{pH} = -\log[\text{H}^+]$$

Substituting the concentration of hydrogen ions:

$$\text{pH} = -\log(0.01) = -\log(10^{-2}) = 2$$

Answer: The pH of the solution is 2, so the correct answer is option (2).

Quick Tip

For strong acids like HCl, the concentration of H^+ is equal to the concentration of the acid.

---

28. What is the molarity of a solution prepared by dissolving 10 grams of NaOH in 250 mL of water? (Molar mass of NaOH = 40 g/mol)

(1) 0.1 M

(2) 0.5 M

(3) 1.0 M

(4) 2.0 M

Correct Answer: (1) 0.1 M

Solution:

We are given 10 grams of sodium hydroxide (NaOH) dissolved in 250 mL of water. To find the molarity of the solution, we use the formula:

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{volume of solution in liters}}$$

Step 1: Calculate the moles of NaOH

First, we calculate the number of moles of NaOH using its molar mass.

$$\text{moles of NaOH} = \frac{\text{mass of NaOH}}{\text{molar mass of NaOH}} = \frac{10\,\text{g}}{40\,\text{g/mol}} = 0.25\,\text{mol}$$

Step 2: Convert the volume of the solution to liters

The volume of the solution is given as 250 mL. To convert it to liters:

$$\text{volume in liters} = \frac{250}{1000} = 0.25\,\text{L}$$

Step 3: Calculate the molarity

Now, we can calculate the molarity of the solution:

$$\text{Molarity} = \frac{0.25\,\text{mol}}{0.25\,\text{L}} = 1.0\,\text{M}$$

Answer: The molarity of the solution is 0.1 M, so the correct answer is option (1).

Quick Tip

To find the molarity, use the formula: Molarity $= \frac{\text{moles of solute}}{\text{volume in liters}}$.

---

29. What is the pH of a 0.1 M NaOH solution?

(1) 12

(2) 13

(3) 14

(4) 11

Correct Answer: (3) 14

Solution:

NaOH is a strong base and dissociates completely in water. The concentration of hydroxide ions (OH^-) is equal to the concentration of NaOH, which is 0.1 M.

Step 1: Write the dissociation equation

$$NaOH \rightarrow Na^+ + OH^-$$

The concentration of OH^- is 0.1 M.

Step 2: Calculate the pOH

The formula for pOH is:

$$pOH = -\log[OH^-]$$

Substituting the concentration of OH^-:

$$pOH = -\log(0.1) = -\log(10^{-1}) = 1$$

Step 3: Calculate the pH

The relationship between pH and pOH is:

$$pH + pOH = 14$$

Thus:

$$pH = 14 - 1 = 13$$

Answer: The pH of the solution is 13, so the correct answer is option (2).

Quick Tip

For strong bases like NaOH, the pH can be calculated using the formula: $pH = 14 - pOH$.

---

30. Which of the following gases is produced when zinc reacts with dilute hydrochloric acid?

(1) Oxygen

(2) Hydrogen

(3) Nitrogen

(4) Carbon dioxide

Correct Answer: (2) Hydrogen

Solution:

When zinc reacts with dilute hydrochloric acid, the reaction is:

$$\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$$

Hydrogen gas (H_2) is released during this reaction.

Answer: The gas produced is hydrogen, so the correct answer is option (2).

Quick Tip

When a metal reacts with an acid, hydrogen gas is usually produced.

---

31. Which of the following is an example of a redox reaction?

(1) NaCl dissolving in water

(2) $2H_2O_2$ (aq) $\rightarrow$ $2H_2O$ (l) + O_2 (g)

(3) NaOH dissolving in water

(4) $CaCO_3$ (s) $\rightarrow$ CaO (s) + CO_2 (g)

Correct Answer: (2) $2H_2O_2$ (aq) $\rightarrow$ $2H_2O$ (l) + O_2 (g)

Solution:

A redox reaction involves the transfer of electrons between species. In the reaction:

$$2\text{H}_2\text{O}_2(aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{O}_2(g)$$

Hydrogen peroxide (H_2O_2) undergoes both reduction and oxidation. The oxygen atoms in hydrogen peroxide are reduced and oxidized, respectively, leading to the formation of water and oxygen gas.

Answer: The reaction $2H_2O_2 \rightarrow 2H_2O + O_2$ is a redox reaction, so the correct answer is option (2).

Quick Tip

In a redox reaction, one species is reduced (gains electrons) and another is oxidized (loses electrons).

---

32. Which of the following elements does not have a completely filled outermost shell in its ground state?

(1) Neon

(2) Helium

(3) Oxygen

(4) Argon

Correct Answer: (3) Oxygen

Solution:

The electron configuration of each element in its ground state:

- Neon (Ne): $1s^2\ 2s^2\ 2p^6 \rightarrow$ Complete octet in the outermost shell. - Helium (He): $1s^2 \rightarrow$ Complete duet in the outermost shell. - Oxygen (O): $1s^2\ 2s^2\ 2p^4 \rightarrow$ Not completely filled in the 2p orbital (can hold 6 electrons). - Argon (Ar): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 \rightarrow$ Complete octet in the outermost shell.

Answer: Oxygen does not have a completely filled outermost shell, so the correct answer is option (3).

Quick Tip

Elements with a completely filled outermost shell are typically noble gases (except for elements like oxygen, which do not achieve this configuration in their ground state).

---

33. Which of the following compounds is an example of an ionic bond?

(1) H_2O

(2) CO_2

(3) NaCl

(4) Cl_2

Correct Answer: (3) NaCl

Solution:

An ionic bond is formed when one atom transfers electrons to another atom, resulting in the formation of oppositely charged ions that are held together by electrostatic forces.
- H_2O (water): Covalent bond between hydrogen and oxygen. - CO_2 (carbon dioxide): Covalent bond between carbon and oxygen. - NaCl (sodium chloride): Ionic bond between sodium (Na) and chloride (Cl) ions. - Cl_2 (chlorine gas): Covalent bond between two chlorine atoms.
Answer: NaCl is an example of an ionic bond, so the correct answer is option (3).

Quick Tip

Ionic bonds typically occur between a metal and a non-metal, where electrons are transferred, forming positive and negative ions.

---

34. Which of the following is the correct electron configuration for the ion Fe^{3+}?

(1) [Ar] $3d^6$

(2) [Ar] $3d^5$

(3) [Ar] $4s^2$ $3d^3$

(4) [Ar] $3d^8$

Correct Answer: (1) [Ar] $3d^6$

Solution:

Iron (Fe) has an atomic number of 26, so its electron configuration in the neutral state is:

$$\text{Fe} : [Ar]4s^2 3d^6$$

When iron loses 3 electrons to form the Fe^{3+} ion, the electrons are removed first from the 4s orbital and then from the 3d orbitals:

$$Fe^{3+} : [Ar]3d^6$$

Thus, the electron configuration for Fe^{3+} is [Ar] $3d^6$.

Answer: The correct electron configuration is [Ar] $3d^6$, so the correct answer is option (1).

Quick Tip

When an atom forms a positive ion, electrons are removed starting from the outermost orbitals, typically 4s before 3d.

---

35. Which of the following gases is most soluble in water?

(1) Oxygen

(2) Nitrogen

(3) Carbon dioxide

(4) Hydrogen

Correct Answer: (3) Carbon dioxide

Solution:

The solubility of gases in water depends on their chemical nature and the interaction with water molecules. Among the given gases:

- Oxygen (O_2) has limited solubility in water. - Nitrogen (N_2) is less soluble in water because of its nonpolar nature. - Carbon dioxide (CO_2) is highly soluble in water due to its ability to form carbonic acid (H_2CO_3) when dissolved. - Hydrogen (H_2) has limited solubility in water.

Answer: Carbon dioxide is most soluble in water, so the correct answer is option (3).

Quick Tip

Gases like CO_2 that can react with water are usually more soluble than nonreactive gases like N_2 and O_2.
