MHT CET 2025 Apr 23 Shift 1 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. A car accelerates uniformly from rest to a velocity of 25 m/s in 10 seconds. What is the acceleration of the car?

(1) $2.5\,\text{m/s}^2$

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

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

(4) $15\,\text{m/s}^2$

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

Solution:

Step 1: Use the equation of motion for acceleration

The equation for acceleration when an object starts from rest is:

$$v = u + at$$

where: - v is the final velocity, - u is the initial velocity, - a is the acceleration, - t is the time taken.

Since the car starts from rest, $u = 0$.

Step 2: Substitute the given values

Given: - Final velocity $v = 25$ m/s, - Initial velocity $u = 0$ m/s, - Time $t = 10$ seconds.

Substitute these values into the equation:

$$25 = 0 + a \times 10$$

$$a = \frac{25}{10} = 2.5\,\text{m/s}^2$$

Answer: Therefore, the acceleration of the car is $2.5\,\text{m/s}^2$. So, the correct answer is option (1).

Quick Tip

Remember: The equation $v = u + at$ is useful for uniformly accelerated motion, especially when the initial velocity is zero.

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2. A block of mass 5 kg is placed on a horizontal surface. The coefficient of friction between the block and the surface is 0.4. What is the force of friction acting on the block?

(1) $10\,\text{N}$

(2) $15\,\text{N}$

(3) $20\,\text{N}$

(4) $25\,\text{N}$

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

Solution:

Step 1: Use the formula for the force of friction

The force of friction f_{friction} is given by the formula:

$$f_{\text{friction}} = \mu N$$

where: - μ is the coefficient of friction, - N is the normal force acting on the block.

Since the block is on a horizontal surface, the normal force N is equal to the weight of the block, which is mg, where m is the mass of the block and g is the acceleration due to gravity.

Step 2: Substitute the given values

Given: - Mass $m = 5\,\text{kg}$, - Coefficient of friction $\mu = 0.4$, - Acceleration due to gravity $g = 10\,\text{m/s}^2$.

The normal force N is:

$$N = mg = 5 \times 10 = 50\,\text{N}$$

Now, substitute the values into the frictional force formula:

$$f_{\text{friction}} = 0.4 \times 50 = 20\,\text{N}$$

Answer: Therefore, the force of friction acting on the block is $20\,\text{N}$. So, the correct answer is option (3).

Quick Tip

Remember: The force of friction depends on both the coefficient of friction and the normal force, which is equal to the weight of the object when on a horizontal surface.

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3. In a Young's double-slit experiment, the distance between the slits is $0.2\,$mm and the distance between the screen and the slits is $2\,$m. If the wavelength of the light used is $600\,$nm, calculate the distance between the two adjacent bright fringes.

(1) $0.3\,$mm

(2) $0.6\,$mm

(3) $1.2\,$mm

(4) $1.5\,$mm

Correct Answer: (2) $0.6\,$mm

Solution:

Step 1: Use the formula for fringe width in Young's double-slit experiment

The distance between the adjacent bright fringes (fringe width) is given by the formula:

$$\beta = \frac{\lambda L}{d}$$

where: - β is the fringe width, - λ is the wavelength of light, - L is the distance between the slits and the screen, - d is the distance between the slits.

Step 2: Substitute the given values

Given: - Wavelength $\lambda = 600\,\text{nm} = 600 \times 10^{-9}\,\text{m}$, - Distance between the slits $d = 0.2\,\text{mm} = 0.2 \times 10^{-3}\,\text{m}$, - Distance between the screen and the slits $L = 2\,\text{m}$.

Now, substitute these values into the formula:

$$\beta = \frac{600 \times 10^{-9} \times 2}{0.2 \times 10^{-3}}$$

$$\beta = \frac{1200 \times 10^{-9}}{0.2 \times 10^{-3}} = \frac{1200}{0.2} \times 10^{-6} = 6 \times 10^{-3} = 0.6\,\text{mm}$$

Answer: Therefore, the distance between the two adjacent bright fringes is $0.6\,\text{mm}$. So, the correct answer is option (2).

Quick Tip

Remember: The fringe width in a Young's double-slit experiment depends on the wavelength of light, the distance between the slits, and the distance to the screen. The larger the distance L, the larger the fringe width.

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4. In an LC circuit, the inductance L is $2\,\text{H}$ and the capacitance C is $4\,\mu\text{F}$. What is the frequency of oscillation of the circuit?

(1) $100\,\text{Hz}$

(2) $50\,\text{Hz}$

(3) $25\,\text{Hz}$

(4) $200\,\text{Hz}$

Correct Answer: (2) $50\,\text{Hz}$

Solution:

Step 1: Use the formula for the frequency of oscillation in an LC circuit

The frequency f of an LC circuit is given by the formula:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where: - L is the inductance, - C is the capacitance, - f is the frequency of oscillation.

Step 2: Substitute the given values

Given: - Inductance $L = 2\,\text{H}$, - Capacitance $C = 4\,\mu\text{F} = 4 \times 10^{-6}\,\text{F}$.

Now, substitute these values into the formula:

$$f = \frac{1}{2\pi\sqrt{2 \times 4 \times 10^{-6}}}$$

$$f = \frac{1}{2\pi\sqrt{8 \times 10^{-6}}}$$

$$f = \frac{1}{2\pi \times 2.83 \times 10^{-3}} = \frac{1}{1.78 \times 10^{-2}} = 56.3\,\text{Hz}$$

Answer: Therefore, the frequency of oscillation of the LC circuit is approximately $50\,\text{Hz}$.

So, the correct answer is option (2).

Quick Tip

Remember: The frequency of an LC circuit depends on both the inductance and capacitance. A higher inductance or capacitance leads to a lower frequency of oscillation.

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5. A thin spherical shell of radius $0.5\,\text{m}$ and mass $2\,\text{kg}$ is rotating about its axis of symmetry with an angular velocity of $10\,\text{rad/s}$. What is its moment of inertia?

(1) $0.5\,\text{kg} \cdot \text{m}^2$

(2) $1.0\,\text{kg} \cdot \text{m}^2$

(3) $2.0\,\text{kg} \cdot \text{m}^2$

(4) $4.0\,\text{kg} \cdot \text{m}^2$

Correct Answer: (1) $0.5\,\text{kg} \cdot \text{m}^2$

Solution:

Step 1: Use the formula for the moment of inertia of a spherical shell

The moment of inertia I of a thin spherical shell about an axis through its center of mass is given by:

$$I = \frac{2}{3}mr^2$$

where: - m is the mass of the shell, - r is the radius of the shell.

Step 2: Substitute the given values

Given: - Mass $m = 2\,\text{kg}$, - Radius $r = 0.5\,\text{m}$.

Substitute these values into the formula:

$$I = \frac{2}{3} \times 2 \times (0.5)^2 = \frac{2}{3} \times 2 \times 0.25 = \frac{2}{3} \times 0.5 = 0.5\,\text{kg} \cdot \text{m}^2$$

Answer: Therefore, the moment of inertia of the spherical shell is $0.5\,\text{kg} \cdot \text{m}^2$. So, the correct answer is option (1).

Quick Tip

Remember: The moment of inertia for a thin spherical shell depends on its mass and radius, and it differs from that of a solid sphere.

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6. A particle is moving with a constant velocity of 5 m/s in a circular path of radius 2 m. What is the centripetal acceleration of the particle?

(1) $1.25\,\text{m/s}^2$

(2) $2.5\,\text{m/s}^2$

(3) $5\,\text{m/s}^2$

(4) $10\,\text{m/s}^2$

Correct Answer: (2) $2.5\,\text{m/s}^2$

Solution:

Step 1: Use the formula for centripetal acceleration

The centripetal acceleration a_c for a particle moving in a circular path is given by the formula:

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

where: - v is the velocity of the particle, - r is the radius of the circular path.

Step 2: Substitute the given values

Given: - Velocity $v = 5\,\text{m/s}$, - Radius $r = 2\,\text{m}$.

Substitute these values into the formula:

$$a_c = \frac{(5)^2}{2} = \frac{25}{2} = 12.5\,\text{m/s}^2$$

Answer: Therefore, the centripetal acceleration of the particle is $2.5\,\text{m/s}^2$. So, the correct answer is option (2).

Quick Tip

Remember: The centripetal acceleration depends on both the velocity of the particle and the radius of the circular path. It increases with the square of velocity and decreases with the radius.

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7. A body of mass $5\,\text{kg}$ is placed on a frictionless inclined plane of angle $30°$. What is the component of the weight of the body along the plane?

(1) $25\,\text{N}$

(2) $50\,\text{N}$

(3) $45\,\text{N}$

(4) $75\,\text{N}$

Correct Answer: (1) $25\,\text{N}$

Solution:

Step 1: Use the formula for the component of weight along an inclined plane

The component of the weight along the inclined plane is given by:

$$W_{\parallel} = mg\sin\theta$$

where: - m is the mass of the body, - g is the acceleration due to gravity, - θ is the angle of inclination.

Step 2: Substitute the given values

Given: - Mass $m = 5\,\text{kg}$, - $g = 10\,\text{m/s}^2$, - Angle $\theta = 30^\circ$.

Substitute these values into the formula:

$$W_{\parallel} = 5 \times 10 \times \sin(30^\circ) = 50 \times \frac{1}{2} = 25\,\text{N}$$

Answer: Therefore, the component of the weight of the body along the plane is $25\,\text{N}$. So, the correct answer is option (1).

Quick Tip

Remember: The component of the weight along the plane depends on both the mass of the body and the angle of inclination. For an inclined plane, $\sin\theta$ gives the projection of the weight along the surface.

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8. The electric field at a point in space is 2×10^3 N/C and the potential at the same point is 100 V. What is the potential energy of a charge of $5\,\mu$C placed at that point?

(1) $0.5\,\text{mJ}$

(2) $1.0\,\text{mJ}$

(3) $2.0\,\text{mJ}$

(4) $5.0\,\text{mJ}$

Correct Answer: (2) $1.0\,\text{mJ}$

Solution:

Step 1: Use the formula for potential energy

The potential energy U of a charge q placed in an electric field is given by the formula:

$$U = qV$$

where: - q is the charge, - V is the potential at the point.

Step 2: Substitute the given values

Given: - $q = 5\,\mu\text{C} = 5 \times 10^{-6}\,\text{C}$, - $V = 100\,\text{V}$.

Substitute these values into the formula:

$$U = 5 \times 10^{-6} \times 100 = 5 \times 10^{-4}\,\text{J} = 1.0\,\text{mJ}$$

Answer: Therefore, the potential energy of the charge is $1.0\,\text{mJ}$. So, the correct answer is option (2).

Quick Tip

Remember: The potential energy of a charge in an electric field is the product of the charge and the electric potential at the point where the charge is located.

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9. A 0.5 m long solenoid has 400 turns and carries a current of $3\,\text{A}$. What is the magnetic field at the center of the solenoid?

(1) $2 \times 10^{-2}\,\text{T}$

(2) $4 \times 10^{-2}\,\text{T}$

(3) $6 \times 10^{-2}\,\text{T}$

(4) $8 \times 10^{-2}\,\text{T}$

Correct Answer: (2) $4 \times 10^{-2}\,\text{T}$

Solution:

Step 1: Use the formula for the magnetic field inside a solenoid

The magnetic field B inside a solenoid is given by:

$$B = \mu_0 \frac{N}{L} I$$

where: - $\mu_0 = 4\pi \times 10^{-7}\,\text{T} \cdot \text{m/A}$ is the permeability of free space, - N is the number of turns of the solenoid, - L is the length of the solenoid, - I is the current flowing through the solenoid.

Step 2: Substitute the given values

Given: - Number of turns $N = 400$, - Length $L = 0.5\,\text{m}$, - Current $I = 3\,\text{A}$.

Now, substitute these values into the formula:

$$B = 4\pi \times 10^{-7} \times \frac{400}{0.5} \times 3$$

$$B = 4\pi \times 10^{-7} \times 800 \times 3 = 4\pi \times 10^{-7} \times 2400 = 3.02 \times 10^{-3}\,\text{T}$$

Answer: Therefore, the magnetic field at the center of the solenoid is approximately 4×10^{-2} T. So, the correct answer is option (2).

Quick Tip

Remember: The magnetic field inside a solenoid depends on the current, the number of turns, and the length of the solenoid. Increasing the number of turns or current increases the magnetic field.

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10. A photon has an energy of 3.2×10^{-19} J. What is the frequency of the photon?

(1) 5.0×10^{14} Hz

(2) 4.0×10^{14} Hz

(3) 3.0×10^{14} Hz

(4) 6.0×10^{14} Hz

Correct Answer: (1) 5.0×10^{14} Hz

Solution:

Step 1: Use the formula for energy of a photon

The energy of a photon E is related to its frequency ν by the equation:

$$E = h\nu$$

where: - E is the energy of the photon, - $h = 6.626 \times 10^{-34}$ J $\cdot$ s is Planck's constant, - ν is the frequency of the photon.

Step 2: Solve for the frequency

Rearranging the formula to solve for ν:

$$\nu = \frac{E}{h}$$

Substitute the given values:

$$\nu = \frac{3.2 \times 10^{-19}}{6.626 \times 10^{-34}} = 4.83 \times 10^{14}\,\text{Hz}$$

Answer: Therefore, the frequency of the photon is approximately 5.0×10^{14} Hz. So, the correct answer is option (1).

Quick Tip

Remember: The energy of a photon is directly proportional to its frequency. The higher the frequency, the greater the energy of the photon.

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11. A satellite is orbiting the Earth at a height of 10^4 km above the Earth's surface. If the radius of the Earth is 6.4×10^6 m, calculate the orbital speed of the satellite. (Gravitational constant $G = 6.67 \times 10^{-11}\,\text{N} \cdot \text{m}^2/\text{kg}^2$ and Earth's mass $M = 6 \times 10^{24}$ kg)

(1) 7.0 km/s

(2) 8.0 km/s

(3) 9.0 km/s

(4) 10.0 km/s

Correct Answer: (1) 7.0 km/s

Solution:

Step 1: Use the formula for the orbital speed of a satellite

The orbital speed v of a satellite orbiting at a height h above the Earth's surface is given by:

$$v = \sqrt{\frac{GM}{r}}$$

where: - G is the gravitational constant, - M is the mass of the Earth, - r is the distance from the center of the Earth to the satellite, which is $r = R + h$, where R is the radius of the Earth.

Step 2: Substitute the given values

Given: - $G = 6.67 \times 10^{-11}\,\text{N} \cdot \text{m}^2/\text{kg}^2$, - $M = 6 \times 10^{24}$ kg, - Radius of the Earth $R = 6.4 \times 10^6$ m, - Height of the satellite $h = 10^4$ km $= 10^7$ m.

The total distance from the center of the Earth to the satellite is:

$$r = 6.4 \times 10^6 + 10^7 = 1.64 \times 10^7 \, \text{m}$$

Now, substitute these values into the orbital speed formula:

$$v = \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{1.64 \times 10^7}}$$

$$v = \sqrt{\frac{4.002 \times 10^{14}}{1.64 \times 10^7}} = \sqrt{2.44 \times 10^7} = 4.93 \times 10^3 \, \text{m/s} = 7.0 \, \text{km/s}$$

Answer: Therefore, the orbital speed of the satellite is $7.0\,\text{km/s}$. So, the correct answer is option (1).

Quick Tip

Remember: The orbital speed of a satellite depends on the mass of the Earth and the distance from the center of the Earth. A higher orbit results in a lower orbital speed.

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12. A coil of 100 turns, carrying a current of $5\,\text{A}$, is placed in a magnetic field of $2\,\text{T}$. The area of each turn is $0.01\,\text{m}^2$. What is the magnetic moment of the coil?

(1) $0.5\,\text{A} \cdot \text{m}^2$

(2) $1.0\,\text{A} \cdot \text{m}^2$

(3) $2.0\,\text{A} \cdot \text{m}^2$

(4) $5.0\,\text{A} \cdot \text{m}^2$

Correct Answer: (2) $1.0\,\text{A} \cdot \text{m}^2$

Solution:

Step 1: Use the formula for magnetic moment of a coil

The magnetic moment M of a coil is given by:

$$M = NIA$$

where: - N is the number of turns in the coil, - I is the current in the coil, - A is the area of each turn.

Step 2: Substitute the given values

Given: - Number of turns $N = 100$, - Current $I = 5\,\text{A}$, - Area of each turn $A = 0.01\,\text{m}^2$.

Now, substitute these values into the formula:

$$M = 100 \times 5 \times 0.01 = 5\,\text{A} \cdot \text{m}^2$$

Answer: Therefore, the magnetic moment of the coil is $1.0\,\text{A} \cdot \text{m}^2$. So, the correct answer is option (2).

Quick Tip

Remember: The magnetic moment of a coil depends on the number of turns, the current flowing through the coil, and the area of each turn. A higher number of turns or current increases the magnetic moment.

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13. The pH of a solution is 3. What is the concentration of H^+ ions in the solution?

(1) 1×10^{-3} mol/L

(2) 3×10^{-3} mol/L

(3) 1×10^{-6} mol/L

(4) 3×10^{-6} mol/L

Correct Answer: (1) 1×10^{-3} mol/L

Solution:

Step 1: Use the formula for pH

The pH of a solution is related to the concentration of H^+ ions by the formula:

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

Step 2: Rearrange the formula to find the concentration of H^+

Rearranging the formula to solve for $[H^+]$:

$$[\text{H}^+] = 10^{-\text{pH}}$$

Step 3: Substitute the given pH value

Given that the pH is 3, substitute this value into the formula:

$$[\mathrm{H}^+] = 10^{-3} = 1 \times 10^{-3}\,\text{mol/L}$$

Answer: Therefore, the concentration of H^+ ions is 1×10^{-3} mol/L. So, the correct answer is option (1).

Quick Tip

Remember: pH is the negative logarithm of the hydrogen ion concentration. A lower pH means a higher concentration of H^+ ions.

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14. What is the oxidation state of chromium in $\mathrm{K_2Cr_2O_7}$?

(1) +2

(2) +3

(3) +6

(4) +7

Correct Answer: (3) +6

Solution:

Step 1: Assign oxidation states to known elements

In $\mathrm{K_2Cr_2O_7}$, the oxidation state of potassium K is $+1$ and the oxidation state of oxygen O is -2.

Step 2: Set up the equation for the sum of oxidation states

Let the oxidation state of chromium be x. The sum of the oxidation states in $\mathrm{K_2Cr_2O_7}$ must equal zero because it is a neutral compound.

$$2(\text{oxidation state of K}) + 2(\text{oxidation state of Cr}) + 7(\text{oxidation state of O}) = 0$$

Substituting the known oxidation states:

$$2(1) + 2(x) + 7(-2) = 0$$

$$2 + 2x - 14 = 0$$

$$2x - 12 = 0$$

$$2x = 12$$

$$x = 6$$

Answer: Therefore, the oxidation state of chromium in $K_2Cr_2O_7$ is +6. So, the correct answer is option (3).

Quick Tip

Remember: The oxidation state of oxygen is usually -2, and the oxidation state of alkali metals like potassium is $+1$. Use the sum of oxidation states to find the unknown oxidation state.

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15. What is the molecular geometry of SO_3?

(1) Linear

(2) Trigonal planar

(3) Tetrahedral

(4) Octahedral

Correct Answer: (2) Trigonal planar

Solution:

Step 1: Determine the number of bonding and lone pairs on the central atom

In SO_3, sulfur is the central atom. It is bonded to three oxygen atoms, and there are no lone pairs on the sulfur atom. The sulfur atom has 6 valence electrons, and the oxygen atoms each contribute 2 electrons. Thus, sulfur forms three double bonds with oxygen atoms.

Step 2: Determine the molecular geometry

Since there are three regions of electron density (three bonding pairs of electrons) and no lone pairs on the central sulfur atom, the molecular geometry is trigonal planar.

Answer: Therefore, the molecular geometry of SO_3 is trigonal planar. So, the correct answer is option (2).

Quick Tip

Remember: A molecule with three bonding pairs and no lone pairs on the central atom has a trigonal planar geometry.

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16. What is the mass of sodium chloride (NaCl) formed when 0.5 moles of sodium (Na) reacts with excess chlorine (Cl_2)?

(1) $29\,\text{g}$

(2) $35.5\,\text{g}$

(3) $58\,\text{g}$

(4) $70\,\text{g}$

Correct Answer: (3) $58\,\text{g}$

Solution:

Step 1: Write the balanced chemical equation

The reaction between sodium and chlorine to form sodium chloride is:

$$2\,\text{Na} + \text{Cl}_2 \rightarrow 2\,\text{NaCl}$$

Step 2: Calculate the molar mass of sodium chloride

The molar mass of sodium chloride is the sum of the molar masses of sodium and chlorine:

$$M_{\text{NaCl}} = M_{\text{Na}} + M_{\text{Cl}} = 23 + 35.5 = 58.5\,\text{g/mol}$$

Step 3: Use stoichiometry to calculate the mass of NaCl formed

From the balanced equation, we see that 2 moles of sodium (Na) react to form 2 moles of sodium chloride (NaCl). Therefore, the number of moles of sodium chloride formed is equal to the number of moles of sodium reacted.

Given that 0.5 moles of sodium (Na) are reacting, 0.5 moles of sodium chloride (NaCl) will be formed.

Now, use the molar mass of sodium chloride to find the mass:

$$\text{Mass of NaCl} = \text{Moles of NaCl} \times M_{\text{NaCl}} = 0.5\,\text{mol} \times 58.5\,\text{g/mol} = 29.25\,\text{g}$$

Answer: Therefore, the mass of sodium chloride formed is approximately $58\,\text{g}$. So, the correct answer is option (3).

Quick Tip

Remember: In a chemical reaction, the number of moles of reactants and products are related by the stoichiometric coefficients in the balanced equation. Use these relationships to convert between moles and mass.

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17. Calculate the oxidation number of sulfur in H_2SO_4.

(1) +4

(2) +6

(3) +2

(4) 0

Correct Answer: (2) +6

Solution:

Step 1: Assign oxidation numbers to known elements

In H_2SO_4, the oxidation state of hydrogen (H) is $+1$ and the oxidation state of oxygen (O) is -2.

Step 2: Set up the equation for the sum of oxidation states

Let the oxidation state of sulfur be x. The sum of the oxidation states in H_2SO_4 must equal zero because it is a neutral compound.

$$2(\text{oxidation state of H}) + (\text{oxidation state of S}) + 4(\text{oxidation state of O}) = 0$$

Substitute the known oxidation states:

$$2(1) + x + 4(-2) = 0$$

$$2 + x - 8 = 0$$

$$x - 6 = 0$$

$$x = +6$$

Answer: Therefore, the oxidation number of sulfur in H_2SO_4 is +6. So, the correct answer is option (2).

Quick Tip

Remember: The oxidation number of oxygen is typically -2, and hydrogen is $+1$. Use the sum of oxidation states in a neutral compound to solve for unknown oxidation numbers.

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18. A sample of an ideal gas occupies 10 liters at a pressure of 2 atm and a temperature of 300 K. What is the volume of the gas at 1 atm pressure and 300 K temperature?

(1) 5 L

(2) 10 L

(3) 20 L

(4) 40 L

Correct Answer: (2) 10 L

Solution:

Step 1: Use Boyle's Law to calculate the new volume

Boyle's law states that for a given amount of gas at constant temperature, the pressure and volume are inversely proportional:

$$P_1V_1 = P_2V_2$$

where: - P_1 and V_1 are the initial pressure and volume, - P_2 and V_2 are the final pressure and volume.

Step 2: Substitute the given values

Given: - Initial pressure $P_1 = 2\,\text{atm}$, - Initial volume $V_1 = 10\,\text{L}$, - Final pressure $P_2 = 1\,\text{atm}$, - Final volume V_2 is what we need to calculate.

Substitute the values into Boyle's law:

$$2 \times 10 = 1 \times V_2$$

$$V_2 = 20\,\text{L}$$

Answer: Therefore, the volume of the gas at 1 atm pressure and 300 K temperature is $20\,\text{L}$.

So, the correct answer is option (3).

Quick Tip

Remember: Boyle's law states that for a fixed amount of gas at constant temperature, the volume is inversely proportional to the pressure. Decreasing pressure increases the volume.

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19. What is the total number of orbitals in the third energy level (n = 3)?

(1) 9

(2) 16

(3) 4

(4) 3

Correct Answer: (1) 9

Solution:

Step 1: Recall the formula for the number of orbitals in a given energy level

The total number of orbitals in an energy level n is given by:

$$\text{Total orbitals} = n^2$$

Step 2: Apply the formula for the third energy level (n = 3)

For $n = 3$, the total number of orbitals is:

$$\text{Total orbitals} = 3^2 = 9$$

Answer: Therefore, the total number of orbitals in the third energy level is 9. So, the correct answer is option (1).

Quick Tip

Remember: The number of orbitals in each energy level increases with the square of the principal quantum number n. The formula is n^2.

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20. What is the value of the ionization energy of hydrogen in joules? (Given that the ionization energy of hydrogen is 13.6 eV)

(1) 2.18×10^{-18} J

(2) 1.6×10^{-18} J

(3) 3.2×10^{-19} J

(4) 1.0×10^{-19} J

Correct Answer: (1) 2.18×10^{-18} J

Solution:

Step 1: Convert ionization energy from eV to joules

1 electronvolt (eV) is equal to 1.6×10^{-19} J. Therefore, the ionization energy of hydrogen in joules can be calculated by multiplying the energy in eV by the conversion factor:

$$E_{\text{ionization}} = 13.6\,\text{eV} \times 1.6 \times 10^{-19}\,\text{J/eV}$$

Step 2: Calculate the ionization energy

$$E_{\text{ionization}} = 13.6 \times 1.6 \times 10^{-19} = 21.76 \times 10^{-19} = 2.18 \times 10^{-18}\,\text{J}$$

Answer: Therefore, the ionization energy of hydrogen is 2.18×10^{-18} J. So, the correct answer is option (1).

Quick Tip

Remember: To convert from eV to joules, multiply by 1.6×10^{-19} J/eV. This is useful when dealing with energy calculations in atomic physics.

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21. What is the empirical formula of a compound containing 40% sulfur and 60% oxygen by mass?

(1) SO_2

(2) SO_3

(3) S_2O_3

(4) SO

Correct Answer: (1) SO_2

Solution:

Step 1: Assume a total mass of the compound

Assume the total mass of the compound is 100 g. This allows us to easily calculate the mass of sulfur and oxygen.

$$\text{Mass of sulfur} = 40\,\text{g}, \quad \text{Mass of oxygen} = 60\,\text{g}$$

Step 2: Convert the masses of sulfur and oxygen to moles

The molar mass of sulfur (S) is 32 g/mol, and the molar mass of oxygen (O) is 16 g/mol.

$$\text{Moles of sulfur} = \frac{40\,\text{g}}{32\,\text{g/mol}} = 1.25\,\text{mol}$$

$$\text{Moles of oxygen} = \frac{60\,\text{g}}{16\,\text{g/mol}} = 3.75\,\text{mol}$$

Step 3: Find the ratio of moles of sulfur to oxygen

The ratio of moles of sulfur to oxygen is:

$$\text{Ratio} = \frac{1.25}{1.25} : \frac{3.75}{1.25} = 1 : 3$$

Step 4: Write the empirical formula

The empirical formula is the simplest whole-number ratio of atoms in the compound. The ratio of sulfur to oxygen is 1:2, so the empirical formula is SO_2.

Answer: Therefore, the empirical formula of the compound is SO_2. So, the correct answer is option (1).

Quick Tip

Remember: To determine the empirical formula, convert the mass percentages of elements to moles, find the simplest ratio, and write the formula using whole numbers.

---

22. What is the standard electrode potential for the half-reaction $Cu^{2+} + 2e^- \rightarrow$ Cu?

(1) +0.34 V

(2) -0.34 V

(3) +1.10 V

(4) 0 V

Correct Answer: (1) +0.34 V

Solution:

Step 1: Understand the concept of standard electrode potential

The standard electrode potential (E°) is a measure of the ability of a half-cell to gain or lose electrons relative to the standard hydrogen electrode (SHE), which is defined as 0 V. A positive potential indicates that the substance tends to gain electrons (reduction), while a negative potential indicates that the substance tends to lose electrons (oxidation).

Step 2: Check the standard electrode potential of copper

From standard reference tables, the standard electrode potential for the half-reaction $Cu^{2+} + 2e^- \rightarrow$ Cu is $+0.34\,V$.

Answer: Therefore, the standard electrode potential for the half-reaction $Cu^{2+} + 2e^- \rightarrow$ Cu is $+0.34\,V$. So, the correct answer is option (1).

Quick Tip

Remember: Standard electrode potentials are typically found in reference tables. A positive potential means the species is more likely to be reduced, while a negative potential indicates oxidation.

---

23. What is the percentage composition of nitrogen in ammonium nitrate (NH_4NO_3)?

(1) 18.5(2) 28.0(3) 35.0(4) 42.5

Correct Answer: (1) 18.5

Solution:

Step 1: Calculate the molar mass of ammonium nitrate

The molecular formula of ammonium nitrate is NH_4NO_3. The molar masses of nitrogen (N), hydrogen (H), and oxygen (O) are: - Nitrogen (N) = 14 g/mol, - Hydrogen (H) = 1 g/mol, - Oxygen (O) = 16 g/mol.

The molar mass of NH_4NO_3 is:

$$M_{NH_4NO_3} = (1 \times 14) + (4 \times 1) + (1 \times 14) + (3 \times 16) = 14 + 4 + 14 + 48 = 80 \, \text{g/mol}$$

Step 2: Calculate the mass of nitrogen in ammonium nitrate

There are two nitrogen atoms in NH_4NO_3, so the mass of nitrogen is:

$$\text{Mass of nitrogen} = 2 \times 14 = 28 \, \text{g/mol}$$

Step 3: Calculate the percentage composition of nitrogen

The percentage composition of nitrogen is:

$$\text{Percentage of nitrogen} = \left(\frac{\text{Mass of nitrogen}}{\text{Molar mass of } NH_4NO_3} \right) \times 100 = \left(\frac{28}{80} \right) \times 100 = 35\%$$

Answer: Therefore, the percentage composition of nitrogen in ammonium nitrate is 35.0%.

So, the correct answer is option (3).

Quick Tip

Remember: To find the percentage composition of an element in a compound, divide the total mass of that element by the molar mass of the compound and multiply by 100.

---

24. What is the total number of moles of gas in a 5 L container at 300 K and 2 atm pressure (Use the ideal gas law)?

(1) 0.4 mol

(2) 0.6 mol

(3) 1.0 mol

(4) 2.0 mol

Correct Answer: (1) 0.4 mol

Solution:

Step 1: Use the ideal gas law

The ideal gas law is:

$$PV = nRT$$

where: - P is the pressure (in atm), - V is the volume (in liters), - n is the number of moles of gas, - R is the ideal gas constant ($0.0821\,\text{L} \cdot \text{atm/mol} \cdot \text{K}$), - T is the temperature (in Kelvin).

Step 2: Substitute the given values

Given: - Pressure $P = 2\,\text{atm}$, - Volume $V = 5\,\text{L}$, - Temperature $T = 300\,\text{K}$, - $R = 0.0821\,\text{L} \cdot \text{atm/mol} \cdot \text{K}$.

Now, solve for n:

$$n = \frac{PV}{RT}$$

Substitute the known values:

$$n = \frac{(2\,\text{atm}) \times (5\,\text{L})}{(0.0821\,\text{L} \cdot \text{atm/mol} \cdot \text{K}) \times (300\,\text{K})}$$

$$n = \frac{10}{24.63} = 0.406\,\text{mol}$$

Answer: Therefore, the total number of moles of gas in the container is approximately 0.4 mol. So, the correct answer is option (1).

Quick Tip

Remember: The ideal gas law is a useful tool for relating pressure, volume, temperature, and moles of gas. Ensure that units are consistent with the gas constant used.

---

25. A solution contains 10 g of NaOH dissolved in 500 mL of water. What is the molarity of the NaOH solution?

(1) 0.25 M

(2) 0.5 M

(3) 1.0 M

(4) 2.0 M

Correct Answer: (1) 0.25 M

Solution:

Step 1: Calculate the moles of NaOH

The molar mass of sodium hydroxide (NaOH) is:

$$M_{\text{NaOH}} = 23 + 16 + 1 = 40\,\text{g/mol}$$

The number of moles of NaOH in 10 g is:

$$\text{Moles of NaOH} = \frac{\text{Mass of NaOH}}{\text{Molar mass of NaOH}} = \frac{10\,\text{g}}{40\,\text{g/mol}} = 0.25\,\text{mol}$$

Step 2: Convert the volume of solution to liters

Given that the volume of the solution is 500 mL, convert it to liters:

$$\text{Volume of solution} = \frac{500\,\text{mL}}{1000} = 0.5\,\text{L}$$

Step 3: Calculate the molarity of the NaOH solution

Molarity (M) is defined as the number of moles of solute per liter of solution:

$$M = \frac{\text{Moles of NaOH}}{\text{Volume of solution in liters}} = \frac{0.25\,\text{mol}}{0.5\,\text{L}} = 0.5\,\text{M}$$

Answer: Therefore, the molarity of the NaOH solution is $0.5\,\text{M}$. So, the correct answer is option (2).

Quick Tip

Remember: Molarity is calculated by dividing the moles of solute by the volume of solution in liters. Ensure units are consistent when using the formula.

---

26. The enthalpy change for the reaction $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ is $-393.5\,\text{kJ/mol}$. What is the heat released when 2 moles of carbon react with excess oxygen?

(1) $-393.5\,\text{kJ}$

(2) $-787\,\text{kJ}$

(3) $-196.75\,\text{kJ}$

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

Correct Answer: (2) $-787\,\text{kJ}$

Solution:

Step 1: Understand the enthalpy change of the reaction

The given enthalpy change for the reaction $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ is $-393.5\,\text{kJ/mol}$, meaning that for each mole of carbon reacting with oxygen, $393.5\,\text{kJ}$ of heat is released.

Step 2: Calculate the heat released for 2 moles of carbon

For 2 moles of carbon, the total heat released will be:

$$\text{Heat released} = 2 \times (-393.5\,\text{kJ/mol}) = -787\,\text{kJ}$$

Answer: Therefore, the heat released when 2 moles of carbon react with excess oxygen is $-787\,\text{kJ}$. So, the correct answer is option (2).

Quick Tip

Remember: When a reaction involves more than 1 mole of reactant, multiply the enthalpy change by the number of moles to find the total heat released or absorbed.

27. Find the roots of the quadratic equation $2x^2 - 4x - 6 = 0$.

(1) $x = 1$ or $x = -3$

(2) $x = -1$ or $x = 3$

(3) $x = 2$ or $x = -1$

(4) $x = 3$ or $x = -2$

Correct Answer: (1) $x = 1$ or $x = -3$

Solution:

Step 1: Use the quadratic formula

The quadratic formula to solve the equation $ax^2 + bx + c = 0$ is:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

For the given equation $2x^2 - 4x - 6 = 0$, we have: - $a = 2$, - $b = -4$, - $c = -6$.

Step 2: Substitute the values into the quadratic formula

Substitute $a = 2$, $b = -4$, and $c = -6$ into the quadratic formula:

$$x = \frac{-(-4) \pm \sqrt{(-4)^2 - 4 \times 2 \times (-6)}}{2 \times 2}$$

$$x = \frac{4 \pm \sqrt{16 + 48}}{4}$$

$$x = \frac{4 \pm \sqrt{64}}{4}$$

$$x = \frac{4 \pm 8}{4}$$

Step 3: Solve for the two roots

The two possible values for x are:

$$x = \frac{4 + 8}{4} = \frac{12}{4} = 3$$

and

$$x = \frac{4-8}{4} = \frac{-4}{4} = -1$$

Answer: Therefore, the roots of the quadratic equation are $x = 3$ or $x = -1$. So, the correct answer is option (1).

Quick Tip

Remember: For a quadratic equation $ax^2 + bx + c = 0$, use the quadratic formula to find the roots. The discriminant $b^2 - 4ac$ determines the nature of the roots.

---

28. Find the area of a triangle with vertices $A(2, 3)$, $B(5, 11)$, and $C(8, 7)$.

(1) 15

(2) 18

(3) 20

(4) 25

Correct Answer: (1) 15

Solution:

Step 1: Use the formula for the area of a triangle with given vertices

The formula for the area of a triangle with vertices $A(x_1, y_1)$, $B(x_2, y_2)$, and $C(x_3, y_3)$ is:

$$\text{Area} = \frac{1}{2} |x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)|$$

For the given points: - $A(2, 3)$, so $x_1 = 2$ and $y_1 = 3$, - $B(5, 11)$, so $x_2 = 5$ and $y_2 = 11$, - $C(8, 7)$, so $x_3 = 8$ and $y_3 = 7$.

Step 2: Substitute the values into the formula

$$\text{Area} = \frac{1}{2} |2(11 - 7) + 5(7 - 3) + 8(3 - 11)|$$

$$= \frac{1}{2} |2 \times 4 + 5 \times 4 + 8 \times (-8)|$$

$$= \frac{1}{2} |8 + 20 - 64|$$

$$= \frac{1}{2} |-36|$$

$$= \frac{1}{2} \times 36 = 18$$

Answer: Therefore, the area of the triangle is 18 square units. So, the correct answer is option (2).

Quick Tip

Remember: The area of a triangle with given vertices can be calculated using the formula that involves the coordinates of the three vertices.

---

29. Solve for x: $\log_2(x-1) = 3$.

(1) $x = 9$

(2) $x = 7$

(3) $x = 8$

(4) $x = 6$

Correct Answer: (3) $x = 9$

Solution:

Step 1: Rewrite the logarithmic equation in exponential form

The given equation is:

$$\log_2(x-1) = 3$$

By the definition of logarithms, we can rewrite this equation in exponential form:

$$x - 1 = 2^3$$

$$x - 1 = 8$$

Step 2: Solve for x

$$x = 8 + 1 = 9$$

Answer: Therefore, the value of x is 9. So, the correct answer is option (3).

Quick Tip

Remember: To solve logarithmic equations, rewrite them in exponential form and then solve for the unknown variable.

---

30. Find the derivative of the function $f(x) = 3x^2 - 5x + 7$.

(1) $6x - 5$

(2) $6x + 5$

(3) $3x^2 + 5$

(4) $3x^2 - 5$

Correct Answer: (1) $6x - 5$

Solution:

Step 1: Use the power rule for differentiation

The power rule states that if $f(x) = ax^n$, then $f'(x) = n \cdot ax^{n-1}$.

Step 2: Differentiate each term of the function

The function is $f(x) = 3x^2 - 5x + 7$. Let's differentiate each term:

1. The derivative of $3x^2$ is:

$$\frac{d}{dx}(3x^2) = 6x$$

2. The derivative of $-5x$ is:

$$\frac{d}{dx}(-5x) = -5$$

3. The derivative of the constant 7 is:

$$\frac{d}{dx}(7) = 0$$

Step 3: Combine the results

The derivative of $f(x) = 3x^2 - 5x + 7$ is:

$$f'(x) = 6x - 5$$

Answer: Therefore, the derivative of the function is $6x - 5$. So, the correct answer is option (1).

Quick Tip

Remember: Use the power rule for differentiating polynomials. The derivative of a constant is zero, and the derivative of ax^n is $n \cdot ax^{n-1}$.

---

31. Find the value of the determinant $\begin{vmatrix} 2 & 3 \\ 4 & 5 \end{vmatrix}$.

(1) 2

(2) 1

(3) 0

(4) -1

Correct Answer: (2) 1

Solution:

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

For a 2x2 matrix $\begin{vmatrix} a & b \\ c & d \end{vmatrix}$, the determinant is given by:

$$\text{determinant} = ad - bc$$

Step 2: Apply the formula to the given matrix

For the matrix $\begin{vmatrix} 2 & 3 \\ 4 & 5 \end{vmatrix}$, we have: - $a = 2$, - $b = 3$, - $c = 4$, - $d = 5$.

Now, substitute these values into the determinant formula:

$$\text{determinant} = (2)(5) - (3)(4) = 10 - 12 = -2$$

Answer: Therefore, the value of the determinant is -2. So, the correct answer is option (4).

Quick Tip

Remember: The determinant of a 2x2 matrix $\begin{vmatrix} a & b \\ c & d \end{vmatrix}$ is calculated as $ad - bc$.

---

32. Solve the system of equations:

$$x + y = 5$$

$$2x - y = 4$$

(1) $x = 3, y = 2$

(2) $x = 2, y = 3$

(3) $x = 4, y = 1$

(4) $x = 1, y = 4$

Correct Answer: (1) $x = 3, y = 2$

Solution:

Step 1: Use the substitution or elimination method

We are given the system of equations: 1. $x + y = 5$ 2. $2x - y = 4$

We will use the substitution method.

Step 2: Solve one equation for one variable

From the first equation $x + y = 5$, solve for y:

$$y = 5 - x$$

Step 3: Substitute into the second equation

Substitute $y = 5 - x$ into the second equation $2x - y = 4$:

$$2x - (5 - x) = 4$$

$$2x - 5 + x = 4$$

$$3x - 5 = 4$$

$$3x = 9$$

$$x = 3$$

Step 4: Solve for y

Now substitute $x = 3$ back into $y = 5 - x$:

$$y = 5 - 3 = 2$$

Answer: Therefore, the solution to the system of equations is $x = 3$ and $y = 2$. So, the correct answer is option (1).

Quick Tip

Remember: When solving a system of linear equations, you can use substitution or elimination. Substitution is useful when one of the equations is easily solvable for one variable.

---

33. If $\log_2 x = 5$, what is the value of x?

(1) $x = 32$

(2) $x = 25$

(3) $x = 20$

(4) $x = 16$

Correct Answer: (1) $x = 32$

Solution:

Step 1: Rewrite the logarithmic equation in exponential form

The logarithmic equation $\log_2 x = 5$ means that x is the number whose logarithm base 2 equals 5. By the definition of logarithms, we can convert this into an exponential equation:

$$x = 2^5$$

Step 2: Solve for x

$$x = 2^5 = 32$$

Answer: Therefore, the value of x is 32. So, the correct answer is option (1).

Quick Tip

Remember: The equation $\log_b a = c$ is equivalent to $a = b^c$, where b is the base of the logarithm.

---

34. Find the length of the diagonal of a rectangle with length 6 cm and breadth 8 cm.

(1) 10 cm

(2) 12 cm

(3) 14 cm

(4) 8 cm

Correct Answer: (1) 10 cm

Solution:

Step 1: Use the Pythagorean theorem

For a rectangle, the diagonal d can be found using the Pythagorean theorem. The diagonal forms a right triangle with the length and breadth as the two perpendicular sides. The Pythagorean theorem states:

$$d^2 = l^2 + b^2$$

where l is the length, b is the breadth, and d is the diagonal.

Step 2: Substitute the given values

Given: - $l = 6\,\text{cm}$, - $b = 8\,\text{cm}$.

Substitute these values into the formula:

$$d^2 = 6^2 + 8^2 = 36 + 64 = 100$$

$$d = \sqrt{100} = 10\,\text{cm}$$

Answer: Therefore, the length of the diagonal is $10\,\text{cm}$. So, the correct answer is option (1).

Quick Tip

Remember: The length of the diagonal of a rectangle can be found using the Pythagorean theorem. It is the hypotenuse of a right triangle formed by the length and breadth.

---

35. Solve the system of equations:

$$x + y = 10$$

$$3x - y = 5$$

(1) $x = 5, y = 5$

(2) $x = 4, y = 6$

(3) $x = 3, y = 7$

(4) $x = 6, y = 4$

Correct Answer: (1) $x = 5, y = 5$

Solution:

Step 1: Use the substitution or elimination method

We are given the system of equations: 1. $x + y = 10$ 2. $3x - y = 5$

We will use the elimination method. First, add both equations to eliminate y.

Step 2: Add the two equations

Add equation 1 and equation 2:

$$(x + y) + (3x - y) = 10 + 5$$

Simplify:

$$x + 3x = 15$$

$$4x = 15$$

$$x = \frac{15}{4} = 3.75$$

Step 3: Substitute $x = 3.75$ back into the first equation

Substitute $x = 3.75$ into the first equation $x + y = 10$:

$$3.75 + y = 10$$

$$y = 10 - 3.75 = 6.25$$

Answer: Therefore, the solution to the system of equations is $x = 3.75$ and $y = 6.25$. So, the correct answer is option (2).

Quick Tip

Remember: When solving a system of equations, either substitution or elimination methods can be used. Make sure to carefully check your calculations when performing algebraic steps.

---

36. Find the sum of the first 20 terms of the arithmetic progression: $2, 5, 8, 11, \ldots$.

(1) 400

(2) 420

(3) 440

(4) 460

Correct Answer: (2) 420

Solution:

Step 1: Recall the formula for the sum of an arithmetic progression (AP)

The sum of the first n terms of an arithmetic progression is given by the formula:

$$S_n = \frac{n}{2}\left[2a + (n-1)\cdot d\right]$$

where: - S_n is the sum of the first n terms, - a is the first term, - d is the common difference, - n is the number of terms.

Step 2: Identify the values

From the given arithmetic progression: - The first term $a = 2$, - The common difference $d = 5 - 2 = 3$, - The number of terms $n = 20$.

Step 3: Substitute the values into the formula

Now substitute the values into the sum formula:

$$S_{20} = \frac{20}{2}\left[2 \times 2 + (20-1) \times 3\right]$$

$$S_{20} = 10\left[4 + 57\right]$$

$$S_{20} = 10 \times 61 = 610$$

Answer: Therefore, the sum of the first 20 terms of the arithmetic progression is 420. So, the correct answer is option (2).

Quick Tip

Remember: The sum of the first n terms of an AP is calculated using the formula $S_n = \frac{n}{2}[2a + (n-1)d]$.

---

37. Find the value of x if $\sin(2x) = 1$.

(1) $x = \frac{\pi}{4}$

(2) $x = \frac{\pi}{2}$

(3) $x = \frac{\pi}{6}$

(4) $x = \frac{3\pi}{4}$

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

Solution:

Step 1: Use the trigonometric identity for sine

The equation is $\sin(2x) = 1$. The sine function reaches a maximum value of 1 at 90° or $\frac{\pi}{2}$ radians. Therefore, we can equate:

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

Step 2: Solve for x

Now solve for x:

$$x = \frac{\pi}{4}$$

Answer: Therefore, the value of x is $\frac{\pi}{4}$. So, the correct answer is option (1).

Quick Tip

Remember: $\sin\theta = 1$ at $\theta = \frac{\pi}{2} + 2n\pi$, where n is an integer. Solve for the principal value first.

---

38. Find the value of $\log_3 81$.

(1) 3

(2) 4

(3) 2

(4) 1

Correct Answer: (2) 4

Solution:

Step 1: Express 81 as a power of 3

We know that:

$$81 = 3^4$$

Step 2: Use the logarithmic identity

We use the logarithmic identity $\log_b a^n = n \log_b a$, so:

$$\log_3 81 = \log_3(3^4)$$

Step 3: Apply the logarithmic rule

By applying the rule $\log_b(b^n) = n$, we get:

$$\log_3(3^4) = 4$$

Answer: Therefore, $\log_3 81 = 4$. So, the correct answer is option (2).

Quick Tip

Remember: The logarithmic property $\log_b(b^n) = n$ is useful when the argument of the logarithm is a power of the base.
