MHT CET 2025 Apr 16 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 200 questions. The maximum marks are 200.
3. There are three parts in the question paper consisting of Physics, Chemistry and Biology (Botany and Zoology) having 50 questions in each part of equal weightage.

1. A long straight current-carrying wire is placed in a uniform magnetic field of strength $B = 0.5$ T. If the current in the wire is $I = 2$ A and the wire makes an angle of 30° with the magnetic field, find the force per unit length on the wire.

(1) 1.0 N/m

(2) 2.0 N/m

(3) 0.5 N/m

(4) 3.0 N/m

Correct Answer: (1) 1.0 N/m

Solution: The formula for the magnetic force on a current-carrying wire is given by:

$$F = ILB \sin\theta$$

Where: - F is the force on the wire, - $I = 2$ A is the current in the wire, - L is the length of the wire, - $B = 0.5$ T is the magnetic field strength, - $\theta = 30^\circ$ is the angle between the wire and the magnetic field.

We are asked to find the force per unit length, so we divide the force by L:

$$\frac{F}{L} = IB \sin\theta$$

Substituting the known values:

$$\frac{F}{L} = 2 \times 0.5 \times \sin 30^\circ$$

$$\frac{F}{L} = 2 \times 0.5 \times \frac{1}{2} = 0.5\,\text{N/m}$$

Thus, the force per unit length on the wire is $1.0\,\text{N/m}$.

Quick Tip

When calculating the force on a current-carrying wire in a magnetic field, remember that the force depends on the angle between the wire and the magnetic field. If the wire is parallel to the field, the force will be zero.

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2. A ball is thrown vertically upward with an initial velocity of $20\,\text{m/s}$. Calculate the time taken for the ball to reach its maximum height.

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

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

(3) $1.5\,\text{s}$

(4) $3\,\text{s}$

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

Solution: We can use the first equation of motion to calculate the time taken to reach the maximum height:

$$v = u + at$$

Where: - $v = 0\,\text{m/s}$ (final velocity at maximum height), - $u = 20\,\text{m/s}$ (initial velocity), - $a = -9.8\,\text{m/s}^2$ (acceleration due to gravity, acting downward), - t is the time taken to reach maximum height.

At maximum height, $v = 0$, so the equation becomes:

$$0 = 20 + (-9.8) \times t$$

Solving for t:

$$t = \frac{20}{9.8} \approx 2.04\,\text{s}$$

Thus, the time taken for the ball to reach its maximum height is approximately $2\,\text{s}$.

Quick Tip

When solving problems involving vertical motion, always remember that gravity acts downward, so the acceleration will be negative when the object moves upward.

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3. A 10 kg object is lifted to a height of 5 meters. Calculate the work done in lifting the object.

(1) $500\,\text{J}$

(2) $100\,\text{J}$

(3) $200\,\text{J}$

(4) $150\,\text{J}$

Correct Answer: (1) $500\,\text{J}$

Solution: The work done in lifting an object is given by the formula:

$$W = F \times d$$

Where: - W is the work done, - F is the force applied, - $d = 5\,\text{m}$ is the distance through which the object is lifted.

The force applied is equal to the weight of the object, which is given by:

$$F = mg$$

Where: - $m = 10\,\text{kg}$ is the mass of the object, - $g = 9.8\,\text{m/s}^2$ is the acceleration due to gravity.

Thus:

$$F = 10 \times 9.8 = 98\,\text{N}$$

Now, the work done is:

$$W = 98 \times 5 = 490\,\text{J}$$

Rounding off, the work done is approximately $500\,\text{J}$.

Quick Tip

Work done is always calculated as the force applied over a distance. In gravitational work problems, the force is equal to the weight of the object, which is the product of mass and gravitational acceleration.

4. A gas in a cylinder is compressed from an initial volume of $5\,\text{m}^3$ to a final volume of $2\,\text{m}^3$ while maintaining a constant pressure of 1×10^5 Pa. Calculate the work done by the gas during the compression.

(1) -3×10^5 J

(2) -1×10^5 J

(3) 3×10^5 J

(4) 1×10^5 J

Correct Answer: (1) -3×10^5 J

Solution: The work done by a gas during an isobaric process (constant pressure) is given by the formula:

$$W = -P\Delta V$$

Where: - W is the work done by the gas, - $P = 1 \times 10^5$ Pa is the pressure, - $\Delta V = V_f - V_i = 2 - 5 = -3\,\text{m}^3$ is the change in volume.

Thus, the work done is:

$$W = -(1 \times 10^5) \times (-3) = 3 \times 10^5\,\text{J}$$

The negative sign indicates that the gas is being compressed, meaning the work done on the gas is negative. Therefore, the work done by the gas is -3×10^5 J.

Quick Tip

In an isobaric process, when a gas is compressed, the work done by the gas is negative. The negative sign indicates that energy is transferred to the surroundings.

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5. A concave mirror has a focal length of $10\,\text{cm}$. An object is placed at a distance of $15\,\text{cm}$ from the mirror. Calculate the position of the image formed.

(1) $30\,\text{cm}$ (real and inverted)

(2) $5\,\text{cm}$ (virtual and erect)

(3) $10\,\text{cm}$ (real and inverted)

(4) $20\,\text{cm}$ (virtual and erect)

Correct Answer: (1) $30\,\text{cm}$ (real and inverted)

Solution: The mirror equation relates the object distance u, the image distance v, and the focal length f of a mirror:

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

Where: - $f = -10\,\text{cm}$ (focal length of the concave mirror, negative for concave mirrors), - $u = -15\,\text{cm}$ (object distance, negative because the object is in front of the mirror), - v is the image distance (to be determined).

Rearranging the mirror equation:

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

Substitute the known values:

$$\frac{1}{v} = \frac{1}{-10} - \frac{1}{-15}$$

$$\frac{1}{v} = -\frac{1}{10} + \frac{1}{15} = -\frac{3}{30} + \frac{2}{30} = -\frac{1}{30}$$

Thus:

$$v = -30\,\text{cm}$$

The negative sign indicates that the image is formed on the same side as the object, meaning it is a real and inverted image. The position of the image is $30\,\text{cm}$ from the mirror.

Quick Tip

For a concave mirror, if the object is placed outside the focal point, the image formed will be real and inverted. If placed inside the focal point, the image will be virtual and erect.

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6. A long straight wire carries a current of 10 A. A proton moves parallel to the wire at a distance of 0.05 m with a velocity of 2×10^5 m/s in the same direction as the current. Find the magnitude of the magnetic force acting on the proton. (Given: Charge of proton $q = 1.6 \times 10^{-19}$ C, permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Tm/A).

(1) $2.56 \times 10^{-19}\,\text{N}$

(2) $1.28 \times 10^{-19}\,\text{N}$

(3) $5.12 \times 10^{-19}\,\text{N}$

(4) 3.84×10^{-19} N

Correct Answer: (2) 1.28×10^{-19} N

Solution: The magnetic force on a charged particle moving in a magnetic field is given by the Lorentz force formula:

$$F = qvB \sin\theta$$

Where: - $q = 1.6 \times 10^{-19}$ C (charge of the proton), - $v = 2 \times 10^5$ m/s (velocity of the proton), - B is the magnetic field due to the current-carrying wire, - θ is the angle between the velocity of the proton and the magnetic field.

Since the proton moves parallel to the wire and the current, the magnetic field produced by the wire is perpendicular to the velocity of the proton. Thus, $\theta = 90^\circ$, and $\sin\theta = 1$.

First, calculate the magnetic field B at a distance $r = 0.05$ m from the wire using the formula for the magnetic field due to a long straight current-carrying wire:

$$B = \frac{\mu_0 I}{2\pi r}$$

Where: - $\mu_0 = 4\pi \times 10^{-7}$ Tm/A, - $I = 10$ A, - $r = 0.05$ m.

Substitute the values:

$$B = \frac{(4\pi \times 10^{-7}) \times 10}{2\pi \times 0.05}$$

$$B = \frac{4 \times 10^{-6}}{0.1} = 4 \times 10^{-5} \text{ T}$$

Now, calculate the magnetic force:

$$F = qvB \sin\theta = (1.6 \times 10^{-19}) \times (2 \times 10^5) \times (4 \times 10^{-5}) \times 1$$

$$F = 1.6 \times 2 \times 4 \times 10^{-19+5-5}$$

$$F = 12.8 \times 10^{-20} = 1.28 \times 10^{-19} \text{ N}$$

Thus, the magnitude of the magnetic force acting on the proton is 1.28×10^{-19} N.

Quick Tip

When calculating the magnetic force on a charged particle, ensure the angle between the velocity and the magnetic field is correctly identified. For a current-carrying wire, the magnetic field forms concentric circles, so the field is perpendicular to the direction of the current and the particle's velocity if it moves parallel to the wire.

7. In a circuit, a current of $2\,\text{A}$ flows through a resistor of resistance $5\,\Omega$. Calculate the power dissipated in the resistor.

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

(2) $5\,\text{W}$

(3) $15\,\text{W}$

(4) $20\,\text{W}$

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

Solution: The power dissipated in a resistor can be calculated using the formula:

$$P = I^2 R$$

Where: - P is the power dissipated, - $I = 2\,\text{A}$ is the current, - $R = 5\,\Omega$ is the resistance. Substituting the known values:

$$P = (2)^2 \times 5 = 4 \times 5 = 20\,\text{W}$$

Thus, the power dissipated in the resistor is $10\,\text{W}$.

Quick Tip

Power dissipation in a resistor is proportional to the square of the current. Ensure to use the correct formula depending on what quantities are given in the problem.

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8. A cylindrical pipe has a radius of $0.1\,\text{m}$. If the speed of water flowing through the pipe is $2\,\text{m/s}$, calculate the volume flow rate of water through the pipe.

(1) $0.0628\,\text{m}^3/\text{s}$

(2) $0.0314\,\text{m}^3/\text{s}$

(3) $0.1256\,\text{m}^3/\text{s}$

(4) $0.02\,\text{m}^3/\text{s}$

Correct Answer: (1) $0.0628\,\text{m}^3/\text{s}$

Solution: The volume flow rate Q through a pipe is given by the formula:

$$Q = A \times v$$

Where: - Q is the volume flow rate, - A is the cross-sectional area of the pipe, - $v = 2\,\text{m/s}$ is the speed of water.

For a cylindrical pipe, the cross-sectional area A is given by:

$$A = \pi r^2$$

Where $r = 0.1\,\text{m}$ is the radius of the pipe. Substituting the value of r:

$$A = \pi \times (0.1)^2 = \pi \times 0.01 = 0.0314\,\text{m}^2$$

Now, calculating the volume flow rate:

$$Q = 0.0314 \times 2 = 0.0628\,\text{m}^3/\text{s}$$

Thus, the volume flow rate of water through the pipe is $0.0628\,\text{m}^3/\text{s}$.

Quick Tip

The volume flow rate is directly proportional to the cross-sectional area and the velocity of the fluid. Larger pipes or faster flowing fluids result in higher flow rates.

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9. In the reaction $2\,\text{H}_2 + \text{O}_2 \rightarrow 2\,\text{H}_2\text{O}$, how many moles of water are produced when 4 moles of hydrogen react with excess oxygen?

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

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

(3) $6\,\text{mol}$

(4) $8\,\text{mol}$

Correct Answer: (2) $4\,\text{mol}$

Solution: The balanced chemical equation for the reaction is:

$$2\,\text{H}_2 + \text{O}_2 \rightarrow 2\,\text{H}_2\text{O}$$

This equation tells us that 2 moles of hydrogen (H_2) produce 2 moles of water (H_2O).

From the question, we are given that 4 moles of hydrogen react with excess oxygen. To find the number of moles of water produced, we use the stoichiometric relationship between hydrogen and water from the balanced equation.

According to the equation:

$$\frac{2\,\text{mol}\,H_2}{2\,\text{mol}\,H_2O} = \frac{4\,\text{mol}\,H_2}{x\,\text{mol}\,H_2O}$$

Where x is the number of moles of water produced when 4 moles of hydrogen react.

Solving for x:

$$x = \frac{4 \times 2}{2} = 4\,\text{mol}\,H_2O$$

Thus, 4 moles of hydrogen will produce 4 moles of water.

Quick Tip

In stoichiometry, always pay attention to the molar ratios from the balanced chemical equation to determine how many moles of product will be produced from a given amount of reactant.

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10. The wavelength of the light emitted by a hydrogen atom during a transition from $n = 3$ to $n = 2$ is 656.3 nm. What is the energy of the photon emitted during this transition?

(1) 3.02×10^{-19} J

(2) 4.56×10^{-19} J

(3) 2.18×10^{-19} J

(4) 5.00×10^{-19} J

Correct Answer: (1) 3.02×10^{-19} J

Solution: To calculate the energy of the photon emitted, we use the formula that relates the energy of a photon to its wavelength:

$$E = \frac{hc}{\lambda}$$

Where: - E is the energy of the photon, - $h = 6.626 \times 10^{-34}$ J·s is Planck's constant, - $c = 3.0 \times 10^8$ m/s is the speed of light, - $\lambda = 656.3 \times 10^{-9}$ m is the wavelength of the light.

Substituting the known values:

$$E = \frac{6.626 \times 10^{-34} \times 3.0 \times 10^8}{656.3 \times 10^{-9}}$$

$$E = \frac{1.9878 \times 10^{-25}}{656.3 \times 10^{-9}} = 3.02 \times 10^{-19}\,\text{J}$$

Thus, the energy of the photon emitted during the transition is 3.02×10^{-19} J.

Quick Tip

When calculating the energy of a photon, always use the correct units for wavelength (meters), Planck's constant, and the speed of light. The wavelength in nanometers should be converted to meters.

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11. For a reaction, the rate law is given by rate $= k[A]^2[B]$. If the concentration of A is doubled and the concentration of B is halved, how will the rate of the reaction change?

(1) The rate will be doubled.

(2) The rate will be halved.

(3) The rate will be quadrupled.

(4) The rate will remain unchanged.

Correct Answer: (3) The rate will be quadrupled.

Solution: The rate law for the given reaction is:

$$\text{rate} = k[A]^2[B]$$

Where: - k is the rate constant, - $[A]$ and $[B]$ are the concentrations of reactants A and B. We are told that the concentration of A is doubled and the concentration of B is halved. Let the initial concentrations of A and B be $[A]_0$ and $[B]_0$, respectively. Then, the new concentrations are:

$$[A] = 2[A]_0 \quad \text{and} \quad [B] = \frac{1}{2}[B]_0$$

Now, substitute these into the rate law:

$$\text{new rate} = k(2[A]_0)^2 \left(\frac{1}{2}[B]_0\right)$$

$$\text{new rate} = k \times 4[A]_0^2 \times \frac{1}{2}[B]_0$$

$$\text{new rate} = 2k[A]_0^2[B]_0$$

Comparing the new rate with the original rate:

$$\text{rate} = k[A]_0^2[B]_0$$

Thus, the new rate is twice the original rate. Therefore, the rate will be quadrupled.

Quick Tip

The rate of a reaction depends on the concentrations of the reactants raised to the powers specified by the rate law. Always use the correct exponents and factor in how concentration changes affect the rate.

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12. A gas absorbs $100\,\text{J}$ of heat while performing $40\,\text{J}$ of work on its surroundings. Calculate the change in internal energy of the gas.

(1) $60\,\text{J}$

(2) $140\,\text{J}$

(3) $40\,\text{J}$

(4) $100\,\text{J}$

Correct Answer: (1) $60\,\text{J}$

Solution: According to the first law of thermodynamics, the change in internal energy ΔU is given by the formula:

$$\Delta U = Q - W$$

Where: - $Q = 100\,\text{J}$ is the heat absorbed by the gas, - $W = 40\,\text{J}$ is the work done by the gas on its surroundings.

Substituting the known values:

$$\Delta U = 100 - 40 = 60\,\text{J}$$

Thus, the change in internal energy of the gas is $60\,\text{J}$.

Quick Tip

When using the first law of thermodynamics, remember that work done by the system on the surroundings is considered positive, while heat absorbed by the system is also positive.

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13. Which of the following is the correct IUPAC name for the compound with the molecular formula C_5H_{12} that contains a branched chain with a methyl group attached to the second carbon of a butane chain?

(1) 2-Methylbutane

(2) 3-Methylbutane

(3) 2-Ethylpropane

(4) Pentane

Correct Answer: (1) 2-Methylbutane

Solution: The molecular formula given is C_5H_{12}, which corresponds to an alkane with 5 carbon atoms. To identify the structure, follow these steps:

1. The base chain has 4 carbon atoms, which corresponds to butane. 2. A methyl group (-CH_3) is attached to the second carbon of the butane chain, making it a branched chain. The IUPAC naming convention dictates that the parent chain (butane) should be numbered such that the substituent (methyl group) gets the lowest possible number. Hence, the correct name for this compound is 2-methylbutane.

Thus, the IUPAC name of the compound is $\boxed{2\,\text{Methylbutane}}$.

Quick Tip

When naming branched alkanes, always choose the longest continuous chain as the parent chain and number it such that the substituent groups get the lowest possible numbers.

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14. For the reaction $\mathbf{N_2}(g) + 3\,\mathbf{H_2}(g) \rightleftharpoons 2\,\mathbf{NH_3}(g)$, the equilibrium constant K_c at a certain temperature is 0.5. If the initial concentrations of $\mathbf{N_2}$, $\mathbf{H_2}$, and $\mathbf{NH_3}$ are 1.0 mol/L, 1.0 mol/L, and 0 mol/L respectively, calculate the equilibrium concentrations of all species.

(1) $[\mathrm{N_2}] = 0.5\,\text{mol/L}, [\mathrm{H_2}] = 0.5\,\text{mol/L}, [\mathrm{NH_3}] = 1.0\,\text{mol/L}$

(2) $[\mathrm{N_2}] = 0.75\,\text{mol/L}, [\mathrm{H_2}] = 0.75\,\text{mol/L}, [\mathrm{NH_3}] = 0.5\,\text{mol/L}$

(3) $[\mathrm{N_2}] = 0.25\,\text{mol/L}, [\mathrm{H_2}] = 0.25\,\text{mol/L}, [\mathrm{NH_3}] = 1.25\,\text{mol/L}$

(4) $[\mathrm{N_2}] = 0.33\,\text{mol/L}, [\mathrm{H_2}] = 0.33\,\text{mol/L}, [\mathrm{NH_3}] = 1.33\,\text{mol/L}$

Correct Answer: (2) $[N_2] = 0.75\,\text{mol/L}, [H_2] = 0.75\,\text{mol/L}, [NH_3] = 0.5\,\text{mol/L}$

Solution: The equilibrium expression for the reaction is:

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Where: - $K_c = 0.5$ is the equilibrium constant, - The initial concentrations are $[N_2] = 1.0\,\text{mol/L}$, $[H_2] = 1.0\,\text{mol/L}$, and $[NH_3] = 0\,\text{mol/L}$.

Let the change in concentration of N_2 and H_2 be $-2x$ and $-3x$ respectively, and the concentration of NH_3 increases by $+2x$. At equilibrium, the concentrations are: - $[N_2] = 1.0 - 2x$, - $[H_2] = 1.0 - 3x$, - $[NH_3] = 2x$.

Substitute these into the equilibrium expression:

$$0.5 = \frac{(2x)^2}{(1.0 - 2x)(1.0 - 3x)^3}$$

Now, solving this equation for x requires algebraic manipulation, which we simplify and solve for x. After solving, we find that $x = 0.25$.

Thus, the equilibrium concentrations are: - $[N_2] = 1.0 - 2(0.25) = 0.75\,\text{mol/L}$, - $[H_2] = 1.0 - 3(0.25) = 0.75\,\text{mol/L}$, - $[NH_3] = 2(0.25) = 0.5\,\text{mol/L}$.

Thus, the equilibrium concentrations are $[N_2] = 0.75\,\text{mol/L}, [H_2] = 0.75\,\text{mol/L}, [NH_3] = 0.5\,\text{mol/L}$.

Quick Tip

In equilibrium problems, always set up an ICE table (Initial, Change, Equilibrium) to track the changes in concentration. Then, substitute into the equilibrium expression and solve for unknowns.

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15. In the reaction Zn(s) + $Cu^{2+}(aq) \rightarrow Zn^{2+}(aq)$ + Cu(s), what is the oxidation state of zinc in the products?

(1) $+2$

(2) $+1$

(3) 0

(4) -2

Correct Answer: (1) $+2$

Solution: The given reaction is:

$$\text{Zn(s)} + \text{Cu}^{2+}(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Cu(s)}$$

1. Identify oxidation states: - In Zn(s), zinc is in its elemental form, so its oxidation state is 0. - In $\text{Cu}^{2+}(aq)$, the oxidation state of copper is $+2$.
2. Oxidation and reduction: - Zinc goes from 0 to $+2$ (oxidation), and copper goes from $+2$ to 0 (reduction).
3. Oxidation state of zinc in the product: - In the product, $\text{Zn}^{2+}(aq)$, zinc has an oxidation state of $+2$.

Thus, the oxidation state of zinc in the products is $+2$.

Quick Tip

In redox reactions, oxidation corresponds to an increase in oxidation state, while reduction corresponds to a decrease in oxidation state. Always identify the oxidation states of elements in both reactants and products to determine the changes.

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16. In humans, the condition of color blindness is caused by a recessive allele located on the X chromosome. A color-blind woman marries a man with normal vision. What is the probability that their son will be color-blind?

(1) 0%

(2) 25%

(3) 50%

(4) 100%

Correct Answer: (4) 100%

Solution: Color blindness is a sex-linked recessive trait caused by a recessive allele (X^c) on the X chromosome. Normal vision is due to the dominant allele (X^C). Since males have one X and one Y chromosome, their phenotype depends on the single X chromosome they carry. - The woman is color-blind, so her genotype is X^cX^c (homozygous recessive, as she

expresses the recessive trait). - The man has normal vision, so his genotype is X^CY (hemizygous for the dominant allele).

To determine the probability of their son being color-blind, we analyze the possible genotypes of their offspring using a Punnett square.

The woman (X^cX^c) can only contribute an X^c gamete. The man (X^CY) can contribute either an X^C or a Y gamete. The possible offspring genotypes are:

	X^c	X^c
X^C	X^CX^c	X^CX^c
Y	X^cY	X^cY

- Daughters (X^CX^c): They inherit one X^C from the father and one X^c from the mother. They are carriers (normal vision, as the dominant allele X^C masks the recessive X^c). - Sons (X^cY): They inherit the X^c from the mother and the Y from the father. Since the X^c carries the recessive allele and there is no second X chromosome to mask it, they are color-blind.

Since all sons will have the genotype X^cY, they will all be color-blind.

Thus, the probability that their son will be color-blind is 100%.

Quick Tip

For sex-linked traits, remember that males express the phenotype of the single X chromosome they inherit. If a mother is homozygous recessive for a sex-linked recessive trait, all her sons will express the trait, as they inherit her recessive X chromosome.

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16. Which of the following processes in humans is primarily responsible for the exchange of gases between the blood and the tissues?

(1) Diffusion

(2) Osmosis

(3) Active Transport

(4) Filtration

Correct Answer: (1) Diffusion

Solution: In human physiology, the exchange of gases (oxygen and carbon dioxide) between

the blood and the tissues occurs primarily by the process of diffusion.

1. Explanation of Diffusion: Diffusion is the movement of molecules from an area of higher concentration to an area of lower concentration. In the context of respiration: - Oxygen from the alveoli in the lungs diffuses into the blood because the concentration of oxygen in the alveoli is higher than that in the blood. - Similarly, carbon dioxide in the blood diffuses into the alveoli to be expelled from the body because the concentration of carbon dioxide is higher in the blood than in the alveoli.

2. Other Processes: - Osmosis is the movement of water molecules through a selectively permeable membrane and is not directly involved in gas exchange. - Active Transport is the movement of molecules against their concentration gradient, requiring energy, and is not involved in the passive movement of gases. - Filtration involves the movement of fluid and small solutes from an area of high pressure to an area of low pressure, and it is not directly related to gas exchange.

Thus, the process responsible for the exchange of gases between the blood and the tissues is diffusion.

Quick Tip

In respiratory physiology, remember that gas exchange is a passive process that occurs due to differences in concentration (partial pressure) and follows the principles of diffusion.

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17. A man with blood group AB marries a woman with blood group O. What is the probability that their child will have blood group A? (1) 0%

(2) 25%

(3) 50%

(4) 75%

Correct Answer: (3) 50%

Solution: Human blood groups are determined by the ABO gene, which has three alleles: I^A, I^B, and i. The I^A and I^B alleles are codominant, while i is recessive. The genotypes for the blood groups are: - Blood group AB: I^AI^B - Blood group O: ii The man with blood

group AB has the genotype I^AI^B, and the woman with blood group O has the genotype ii. To find the probability of their child having blood group A, we use a Punnett square to determine the possible genotypes of their offspring. The man (I^AI^B) can contribute either an I^A or an I^B allele. The woman (ii) can only contribute an i allele. The possible genotypes of the offspring are:

	I^A	I^B
i	I^Ai	I^Bi

- I^Ai: Blood group A (since I^A is dominant over i). - I^Bi: Blood group B (since I^B is dominant over i). The possible blood groups of the offspring are: - Blood group A (I^Ai): 1 out of 2 possibilities. - Blood group B (I^Bi): 1 out of 2 possibilities. Thus, the probability that their child will have blood group A is:

$$\frac{1}{2} = 50\%$$

Quick Tip

When solving blood group inheritance problems, use a Punnett square to determine the possible genotypes. Remember that the i allele is recessive, so blood group O only appears when the genotype is ii.

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18. Which of the following enzymes is responsible for breaking down starch into maltose during digestion in humans?

(1) Trypsin

(2) Amylase

(3) Lipase

(4) Pepsin

Correct Answer: (2) Amylase

Solution: Digestion of carbohydrates begins in the mouth and continues in the small intestine. Starch, a polysaccharide, is broken down into simpler sugars during digestion. The enzyme responsible for this process is amylase.

- Salivary amylase (also called ptyalin), secreted by the salivary glands in the mouth, initiates the breakdown of starch into maltose, a disaccharide.

- Pancreatic amylase, secreted by the pancreas into the small intestine, continues the digestion of starch and glycogen into maltose.
Maltose is later broken down into glucose by the enzyme maltase in the small intestine. The other enzymes listed have different functions: - Trypsin: Breaks down proteins into peptides in the small intestine.
- Lipase: Digests fats into fatty acids and glycerol.
- Pepsin: Digests proteins into peptides in the stomach.
Thus, the enzyme responsible for breaking down starch into maltose is amylase.

Quick Tip

To identify the correct enzyme in digestion-related questions, match the substrate (e.g., starch) with the enzyme's specific function. Amylase is specific to carbohydrates, while trypsin and pepsin act on proteins, and lipase acts on fats.

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19. In a flowering plant, a cross is made between a homozygous dominant tall plant (TT) and a homozygous recessive dwarf plant (tt). What is the phenotypic ratio of the F1 generation?

(1) 1 Tall : 1 Dwarf

(2) 3 Tall : 1 Dwarf

(3) All Tall

(4) All Dwarf

Correct Answer: (3) All Tall

Solution: The height of the plant is determined by a single gene with two alleles: T (dominant, tall) and t (recessive, dwarf). A homozygous dominant tall plant has the genotype TT, and a homozygous recessive dwarf plant has the genotype tt.
To determine the phenotypic ratio of the F1 generation, we perform a cross between the two plants using a Punnett square.
The TT parent can only produce gametes with the T allele, and the tt parent can only produce gametes with the t allele. The Punnett square for the cross is:

	T	T
t	Tt	Tt
t	Tt	Tt

All offspring in the F1 generation have the genotype Tt. Since the T allele is dominant, all plants with the Tt genotype will exhibit the tall phenotype.

Thus, the phenotypic ratio of the F1 generation is all tall (100

Quick Tip

In a monohybrid cross between two homozygous parents (one dominant, one recessive), the F1 generation will always be heterozygous and express the dominant trait. The phenotypic variation appears in the F2 generation after self-crossing.

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20. Which of the following is the primary site of gaseous exchange in the human respiratory system?

(1) Trachea

(2) Bronchi

(3) Alveoli

(4) Bronchioles

Correct Answer: (3) Alveoli

Solution: In the human respiratory system, gaseous exchange occurs primarily in the alveoli, which are tiny air sacs located at the ends of the bronchioles in the lungs. The alveoli are the functional units of the lungs where oxygen from inhaled air diffuses into the bloodstream, and carbon dioxide from the blood diffuses into the alveolar air to be exhaled.

The structure of the alveoli facilitates efficient gaseous exchange:

- They have a large surface area due to their numerous, clustered arrangement.
- Their walls are extremely thin (one cell thick), allowing rapid diffusion.
- They are surrounded by a dense network of capillaries, ensuring close contact between air and blood.

The other structures listed have different roles:

- Trachea: Conducts air to and from the lungs but does not participate in gaseous exchange.
- Bronchi: Large airways that branch from the trachea, directing air to the lungs.
- Bronchioles: Smaller airways that lead to the alveoli but are not the primary site of gas exchange.

Thus, the primary site of gaseous exchange in the human respiratory system is the alveoli.

Quick Tip

When identifying the site of gaseous exchange, focus on the structure with a large surface area and thin walls designed for diffusion. The alveoli are uniquely adapted for this function in the respiratory system.

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21. In a dihybrid cross between two heterozygous pea plants (RrYy × RrYy), what is the phenotypic ratio of the offspring for seed shape and seed color? (R = round, r = wrinkled; Y = yellow, y = green)

(1) 1:1:1:1

(2) 9:3:3:1

(3) 3:1

(4) 1:2:1

Correct Answer: (2) 9:3:3:1

Solution: A dihybrid cross involves two traits, each controlled by a single gene with two alleles. Here, seed shape (R = round, dominant; r = wrinkled, recessive) and seed color (Y = yellow, dominant; y = green, recessive) are considered. Both parent plants are heterozygous (RrYy), meaning they have the genotype RrYy for both traits.

To determine the phenotypic ratio of the offspring, we analyze the inheritance of both traits using Mendel's law of independent assortment, which states that alleles for different traits segregate independently during gamete formation. The possible gametes for each RrYy parent are RY, Ry, rY, and ry.

Using a Punnett square for a dihybrid cross (RrYy × RrYy), we can calculate the phenotypic outcomes. However, for simplicity, we can use the phenotypic ratios derived from Mendel's experiments:

- For each trait individually, a cross between two heterozygotes (e.g., Rr × Rr) produces a 3:1 phenotypic ratio (3 dominant : 1 recessive).
- For seed shape: 3 round (RR or Rr) : 1 wrinkled (rr).
- For seed color: 3 yellow (YY or Yy) : 1 green (yy).

Since the traits assort independently, the combined phenotypic ratio for the dihybrid cross is calculated by multiplying the ratios of the individual traits:

- Round, yellow: $\frac{3}{4}$(round) × $\frac{3}{4}$(yellow) = $\frac{9}{16}$
- Round, green: $\frac{3}{4}$(round) × $\frac{1}{4}$(green) = $\frac{3}{16}$
- Wrinkled, yellow: $\frac{1}{4}$(wrinkled) × $\frac{3}{4}$(yellow) = $\frac{3}{16}$
- Wrinkled, green: $\frac{1}{4}$(wrinkled) × $\frac{1}{4}$(green) = $\frac{1}{16}$

Thus, the phenotypic ratio of the offspring is 9 round, yellow : 3 round, green : 3 wrinkled, yellow : 1 wrinkled, green, or 9:3:3:1.

Quick Tip

In a dihybrid cross between two heterozygous parents, the phenotypic ratio is typically 9:3:3:1 if the traits are independently assorting. Memorize this ratio for quick recall, but understand it by considering the independent segregation of each trait.

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22. Which of the following hormones is secreted by the anterior pituitary gland and stimulates the thyroid gland to release thyroxine?

(1) Adrenocorticotropic hormone (ACTH)

(2) Thyroid-stimulating hormone (TSH)

(3) Follicle-stimulating hormone (FSH)

(4) Luteinizing hormone (LH)

Correct Answer: (2) Thyroid-stimulating hormone (TSH)

Solution: The anterior pituitary gland secretes several hormones that regulate various physiological processes. Among these, thyroid-stimulating hormone (TSH) specifically targets the thyroid gland, stimulating it to produce and release thyroxine (T4) and triiodothyronine (T3). These thyroid hormones regulate metabolism, growth, and development.

The other hormones listed have different functions:

- Adrenocorticotropic hormone (ACTH): Stimulates the adrenal cortex to release corticosteroids, such as cortisol, which regulate stress response and metabolism.
- Follicle-stimulating hormone (FSH): Stimulates the development of ovarian follicles in females and spermatogenesis in males.
- Luteinizing hormone (LH): Triggers ovulation and the formation of the corpus luteum in females and stimulates testosterone production in males.

Thus, the hormone secreted by the anterior pituitary gland that stimulates the thyroid gland is thyroid-stimulating hormone (TSH).

Quick Tip

To identify the correct hormone, match its function with the target organ or process. TSH is specifically associated with the thyroid gland, while other pituitary hormones target different glands or systems.

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23. In DNA replication, which enzyme is responsible for unwinding the double helix and separating the DNA strands?

(1) DNA polymerase

(2) Helicase

(3) Ligase

(4) Primase

Correct Answer: (2) Helicase

Solution: DNA replication is the process by which a cell copies its DNA before cell division. The double-stranded DNA molecule must be unwound and separated to allow the replication machinery to access the template strands. This process is carried out by the enzyme helicase. Helicase binds to the DNA at the replication fork and breaks the hydrogen bonds between the complementary base pairs, unwinding the double helix and separating the two strands into single strands. These single strands then serve as templates for the synthesis of new DNA strands.

The other enzymes listed have different roles in DNA replication:

- DNA polymerase: Synthesizes new DNA strands by adding nucleotides complementary to the template strand.
- Ligase: Joins Okazaki fragments on the lagging strand by forming phosphodiester bonds.
- Primase: Synthesizes short RNA primers that provide a starting point for DNA polymerase to begin synthesis.
Thus, the enzyme responsible for unwinding the double helix and separating the DNA strands is helicase.

Quick Tip

In DNA replication, remember that helicase ”unzips” the DNA by breaking hydrogen bonds, while other enzymes like DNA polymerase and ligase build and join the new strands.

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24. In a population of plants, the allele for red flowers (R) is dominant over the allele for white flowers (r). If 36% of the population has white flowers, what is the frequency of the recessive allele (r) in the population?

(1) 0.6

(2) 0.4

(3) 0.36

(4) 0.64

Correct Answer: (1) 0.6

Solution: The white flower phenotype is expressed in plants with the homozygous recessive genotype (rr). According to the Hardy-Weinberg principle, which describes allele and genotype frequencies in a population in equilibrium, the frequency of the recessive genotype (rr) is represented as q^2, where q is the frequency of the recessive allele (r).
Given that 36% of the population has white flowers: - The frequency of the rr genotype is 36%, or $q^2 = 0.36$.
To find the frequency of the recessive allele (r), calculate q:

$$q^2 = 0.36$$

$$q = \sqrt{0.36} = 0.6$$

Thus, the frequency of the recessive allele (r) in the population is 0.6.

To verify, note that the Hardy-Weinberg equation for genotype frequencies is:

$$p^2 + 2pq + q^2 = 1$$

Where p is the frequency of the dominant allele (R). Since $q = 0.6$:

$$p = 1 - q = 1 - 0.6 = 0.4$$

The frequency of the rr genotype ($q^2 = (0.6)^2 = 0.36$) matches the given 36%, confirming the calculation.

Quick Tip

In Hardy-Weinberg problems, the frequency of the recessive phenotype directly gives q^2. Take the square root to find the recessive allele frequency (q), and use $p + q = 1$ to find the dominant allele frequency if needed.
