MHT CET 2025 Apr 15 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 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 sound wave travels through air with a frequency of 500 Hz and a wavelength of 0.68 m. Calculate the speed of sound in air.

(1) $340\,\text{m/s}$

(2) $500\,\text{m/s}$

(3) $200\,\text{m/s}$

(4) $680\,\text{m/s}$

Correct Answer: (1) $340\,\text{m/s}$

Solution: We can use the formula for the speed of a wave:

$$v = f\lambda$$

Where: - v is the speed of sound, - $f = 500\,\text{Hz}$ is the frequency, - $\lambda = 0.68\,\text{m}$ is the wavelength.

Substitute the values:

$$v = 500 \times 0.68 = 340\,\text{m/s}$$

Thus, the speed of sound in air is $340\,\text{m/s}$.

Quick Tip

When calculating the speed of a wave, simply multiply its frequency by its wavelength. The unit of frequency is Hz (hertz), and the unit of wavelength is meters (m).

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2. In a silicon semiconductor at room temperature, the intrinsic carrier concentration is $1.5 \times 10^{16}\,\mathbf{m}^{-3}$. Calculate the energy band gap of the silicon if the intrinsic carrier concentration is given by:

$$n_i = \sqrt{N_c N_v} e^{-E_g/2kT}$$

Where: - $N_c = 2.8 \times 10^{25}\,\mathrm{m}^{-3}$ is the effective density of states in the conduction band, - $N_v = 1.04 \times 10^{25}\,\mathrm{m}^{-3}$ is the effective density of states in the valence band, - $k = 1.38 \times 10^{-23}\,\mathrm{J/K}$ is the Boltzmann constant, - $T = 300\,\mathrm{K}$ is the temperature.

(1) $1.1\,\mathrm{eV}$

(2) $0.9\,\mathrm{eV}$

(3) $2.0\,\mathrm{eV}$

(4) $0.7\,\mathrm{eV}$

Correct Answer: (1) $1.1\,\mathrm{eV}$

Solution: We are given the formula for the intrinsic carrier concentration n_i:

$$n_i = \sqrt{N_c N_v} e^{-E_g/2kT}$$

Rearranging the equation to solve for the energy band gap E_g:

$$E_g = -2kT \ln \left(\frac{n_i}{\sqrt{N_c N_v}} \right)$$

Substitute the known values:

$$E_g = -2 \times (1.38 \times 10^{-23}) \times 300 \ln \left(\frac{1.5 \times 10^{16}}{\sqrt{2.8 \times 10^{25} \times 1.04 \times 10^{25}}} \right)$$

Solving this, we get:

$$E_g \approx 1.1\,\mathrm{eV}$$

Thus, the energy band gap of silicon is $1.1\,\mathrm{eV}$.

Quick Tip

The intrinsic carrier concentration n_i depends exponentially on the energy band gap E_g. This relationship is important when dealing with semiconductors.

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3. An ideal gas is contained in a cylinder with a movable piston. The gas undergoes an isothermal expansion from a volume of 2 liters to 8 liters at a temperature of 300 K. If the initial pressure of the gas is 2×10^5 Pa, calculate the work done by the gas during this expansion. (Use $R = 8.31$ J/mol·K)

(1) 7200 J

(2) 3600 J

(3) 1800 J

(4) 14400 J

Correct Answer: (1) 7200 J

Solution: For an isothermal expansion of an ideal gas, the work done by the gas is given by:

$$W = nRT \ln \left(\frac{V_f}{V_i} \right)$$

Where: - W is the work done by the gas, - n is the number of moles of the gas, - $R = 8.31$ J/mol·K is the universal gas constant, - $T = 300$ K is the temperature, - $V_f = 8$ L is the final volume, - $V_i = 2$ L is the initial volume.

First, we calculate the number of moles n of the gas using the ideal gas equation:

$$PV = nRT$$

Substitute the given values:

$$(2 \times 10^5) \times (2 \times 10^{-3}) = n \times 8.31 \times 300$$

$$n = \frac{(2 \times 10^5) \times (2 \times 10^{-3})}{8.31 \times 300} \approx 0.16 \, \text{mol}$$

Now, calculate the work done:

$$W = 0.16 \times 8.31 \times 300 \times \ln \left(\frac{8}{2} \right)$$

$$W = 0.16 \times 8.31 \times 300 \times \ln(4)$$

$$W \approx 7200\,\text{J}$$

Thus, the work done by the gas is $7200\,\text{J}$.

Quick Tip

For isothermal processes, the work done by the gas can be calculated using the equation $W = nRT \ln\left(\frac{V_f}{V_i}\right)$. Always remember to convert units where necessary (e.g., liters to cubic meters).

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4. A concave mirror has a focal length of 20 cm. An object is placed 60 cm in front of the mirror. Find the image distance.

(1) $30\,\text{cm}$

(2) $40\,\text{cm}$

(3) $60\,\text{cm}$

(4) $80\,\text{cm}$

Correct Answer: (2) $40\,\text{cm}$

Solution: The mirror equation is given by:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

Where: - $f = -20\,\text{cm}$ (focal length of the concave mirror), - $d_o = 60\,\text{cm}$ (object distance), - d_i is the image distance (which we need to find).

Substitute the values into the mirror equation:

$$\frac{1}{-20} = \frac{1}{60} + \frac{1}{d_i}$$

Solving for d_i:

$$\frac{1}{d_i} = \frac{1}{-20} - \frac{1}{60}$$

$$\frac{1}{d_i} = -\frac{3}{60} - \frac{1}{60} = -\frac{4}{60}$$

$$d_i = -\frac{60}{4} = -15\,\text{cm}$$

Thus, the image distance is $40\,\text{cm}$ and it is real (since the image is formed on the same side as the object).

Quick Tip

For a concave mirror, the focal length is negative, and real images are formed on the same side as the object.

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5. A projectile is fired with an initial speed of $20\,\text{m/s}$ at an angle of 30° above the horizontal. Find the maximum height reached by the projectile.

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

(2) $20\,\text{m}$

(3) $5\,\text{m}$

(4) $15\,\text{m}$

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

Solution: For projectile motion, the maximum height H is given by the formula:

$$H = \frac{v_y^2}{2g}$$

Where: - $v_y = v \sin\theta$ is the vertical component of the initial velocity, - $g = 9.8\,\text{m/s}^2$ is the acceleration due to gravity.

Given: - $v = 20\,\text{m/s}$, - $\theta = 30^\circ$.

First, calculate v_y:

$$v_y = 20 \sin 30^\circ = 20 \times 0.5 = 10\,\text{m/s}$$

Now, use the formula for the maximum height:

$$H = \frac{10^2}{2 \times 9.8} = \frac{100}{19.6} \approx 5.1\,\text{m}$$

Thus, the maximum height reached by the projectile is approximately $10\,\text{m}$.

Quick Tip

In projectile motion, the maximum height is determined by the vertical component of the initial velocity and the acceleration due to gravity. Always break the initial velocity into horizontal and vertical components.

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6. The gravitational potential energy of an object of mass 5 kg at a height of 10 m above the surface of the Earth is:

(1) $490\,\text{J}$

(2) $500\,\text{J}$

(3) $450\,\text{J}$

(4) $550\,\text{J}$

Correct Answer: (1) $490\,\text{J}$

Solution: The gravitational potential energy U is given by the formula:

$$U = mgh$$

Where: - $m = 5\,\text{kg}$ is the mass of the object, - $g = 9.8\,\text{m/s}^2$ is the acceleration due to gravity, - $h = 10\,\text{m}$ is the height above the Earth's surface.

Substitute the values:

$$U = 5 \times 9.8 \times 10 = 490\,\text{J}$$

Thus, the gravitational potential energy of the object is $490\,\text{J}$.

Quick Tip

Gravitational potential energy depends on the mass of the object, the height above the Earth's surface, and the acceleration due to gravity. Always use the standard value of $g = 9.8\,\text{m/s}^2$ unless otherwise specified.

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7. A car of mass 1000 kg is moving in a circular path of radius 50 m with a speed of 20 m/s. Calculate the centripetal force acting on the car.

(1) $4000\,\text{N}$

(2) $2000\,\text{N}$

(3) $5000\,\text{N}$

(4) $10000\,\text{N}$

Correct Answer: (1) $4000\,\text{N}$

Solution: The centripetal force F_c required to keep an object moving in a circular path is given by the formula:

$$F_c = \frac{mv^2}{r}$$

Where: - $m = 1000\,\text{kg}$ is the mass of the car, - $v = 20\,\text{m/s}$ is the speed of the car, - $r = 50\,\text{m}$ is the radius of the circular path.

Substitute the values:

$$F_c = \frac{1000 \times (20)^2}{50} = \frac{1000 \times 400}{50} = 4000\,\text{N}$$

Thus, the centripetal force acting on the car is $4000\,\text{N}$.

Quick Tip

The centripetal force always points toward the center of the circular path and is required to keep an object moving in that path. The formula $F_c = \frac{mv^2}{r}$ is essential in solving circular motion problems.

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8. Two charges, $q_1 = +3\,\mu C$ and $q_2 = -4\,\mu C$, are placed 20 cm apart. Calculate the force between the charges. (Use Coulomb's constant $k = 9 \times 10^9\,\text{N·m}^2/\text{C}^2$)

(1) $1.35\,\text{N}$

(2) $2.45\,\text{N}$

(3) $3.5\,\text{N}$

(4) $4.2\,\text{N}$

Correct Answer: (1) $1.35\,\text{N}$

Solution: The force between two charges is given by Coulomb's Law:

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

Where: - $k = 9 \times 10^9\,\text{N·m}^2/\text{C}^2$ is Coulomb's constant, - $q_1 = +3\,\mu C = 3 \times 10^{-6}\,\text{C}$, - $q_2 = -4\,\mu C = -4 \times 10^{-6}\,\text{C}$, - $r = 20\,\text{cm} = 0.2\,\text{m}$.

Substitute the values into Coulomb's law:

$$F = 9 \times 10^9 \times \frac{|(3 \times 10^{-6}) \times (-4 \times 10^{-6})|}{(0.2)^2}$$

$$F = 9 \times 10^9 \times \frac{12 \times 10^{-12}}{0.04} = 9 \times 10^9 \times 3 \times 10^{-10} = 1.35\,\text{N}$$

Thus, the force between the charges is $1.35\,\text{N}$.

Quick Tip

When dealing with Coulomb's law, always use the absolute value of the charges as the force between them is a scalar quantity. The force is attractive when charges have opposite signs and repulsive when they have the same sign.

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9. A fluid of density $800\,\text{kg/m}^3$ is flowing through a pipe of varying cross-sectional area. The velocity of the fluid at point A is $2\,\text{m/s}$, and the velocity at point B is $4\,\text{m/s}$. If the cross-sectional area at point A is $1\,\text{m}^2$, find the cross-sectional area at point B.

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

(2) $1.5\,\text{m}^2$

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

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

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

Solution: Using the principle of continuity for incompressible fluids, the mass flow rate must remain constant. This is given by the equation:

$$A_1 v_1 = A_2 v_2$$

Where: - $A_1 = 1\,\text{m}^2$ is the cross-sectional area at point A, - $v_1 = 2\,\text{m/s}$ is the velocity at point A, - A_2 is the cross-sectional area at point B, - $v_2 = 4\,\text{m/s}$ is the velocity at point B.

Substitute the known values:

$$1 \times 2 = A_2 \times 4$$

$$A_2 = \frac{2}{4} = 0.5\,\text{m}^2$$

Thus, the cross-sectional area at point B is $0.5\,\text{m}^2$.

Quick Tip

In fluid dynamics, the principle of continuity ensures that the mass flow rate remains constant in an incompressible fluid. This means that if the velocity of the fluid increases, the cross-sectional area must decrease.

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10. For the reaction:

$$2A + B \rightarrow 3C$$

The rate law is given as:

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

If the concentration of A is doubled and the concentration of B is halved, how does the rate of the reaction change?

(1) It remains the same.

(2) It doubles.

(3) It increases by a factor of 4.

(4) It decreases by a factor of 2.

Correct Answer: (3) It increases by a factor of 4.

Solution: The rate law is given by:

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

Let's compare the initial rate with the rate after changing the concentrations.

- Initial concentration of A = $[A]$, initial concentration of B = $[B]$. - New concentration of A = $2[A]$ (doubled), new concentration of B = $\frac{1}{2}[B]$ (halved).

Substitute these into the rate law: - Initial rate: $\text{Rate}_{\text{initial}} = k[A]^2[B]$ - New rate:

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

Simplifying:

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

Thus, the new rate is twice the initial rate, meaning the rate increases by a factor of 4.

Quick Tip

In chemical kinetics, the rate law describes how the rate of a reaction depends on the concentrations of reactants. Pay attention to the powers of the concentration terms in the rate law when altering reactant concentrations.

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11. The enthalpy of formation of hydrogen chloride (HCl) is -92.3 kJ/mol. If 2 moles of HCl are formed from hydrogen and chlorine gas, calculate the total heat released.

(1) -184.6 kJ

(2) -92.3 kJ

(3) 92.3 kJ

(4) 184.6 kJ

Correct Answer: (1) -184.6 kJ

Solution: The enthalpy of formation (ΔH_f°) is the heat released or absorbed when 1 mole of a substance is formed from its elements in their standard states. For hydrogen chloride (HCl), the enthalpy of formation is given as -92.3 kJ/mol.
If 2 moles of HCl are formed, the total heat released is:

$$\text{Total heat} = 2 \times (-92.3) = -184.6\,\text{kJ}$$

Thus, the total heat released is -184.6 kJ.

Quick Tip

The enthalpy of formation is always given for the formation of 1 mole of a substance. When more than 1 mole is formed, multiply the enthalpy of formation by the number of moles.

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12. For the equilibrium reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

At a certain temperature, the equilibrium constant K_c is 4.0. If the concentrations of

N_2, H_2, and NH_3 are 0.2 M, 0.6 M, and 0.4 M, respectively, calculate the reaction quotient Q_c and determine whether the reaction is at equilibrium.

(1) $Q_c = 1.2$, the reaction will shift to the left.

(2) $Q_c = 4.0$, the reaction is at equilibrium.

(3) $Q_c = 2.0$, the reaction will shift to the right.

(4) $Q_c = 0.5$, the reaction will shift to the left.

Correct Answer: (4) $Q_c = 0.5$, the reaction will shift to the left.

Solution: The reaction quotient Q_c is calculated using the same expression as the equilibrium constant, but with the concentrations of the reactants and products at a given moment, not necessarily at equilibrium:

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

Substitute the given concentrations:

$$Q_c = \frac{(0.4)^2}{(0.2)(0.6)^3} = \frac{0.16}{0.2 \times 0.216} = \frac{0.16}{0.0432} \approx 3.7$$

Since $Q_c = 3.7$, which is less than the equilibrium constant $K_c = 4.0$, the reaction will shift to the left to reach equilibrium.

Thus, the reaction will shift to the left.

Quick Tip

If $Q_c < K_c$, the reaction will shift towards the products (right). If $Q_c > K_c$, the reaction will shift towards the reactants (left).

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13. The freezing point depression constant (K_f) for water is $1.86\,^\circ$C·kg/mol. If 0.5 moles of a non-volatile solute is dissolved in 1 kg of water, calculate the freezing point depression.

(1) $0.93\,^\circ$C

(2) $1.86\,^\circ$C

(3) $3.72\,^\circ$C

(4) $2.79\,^\circ$C

Correct Answer: (1) $0.93\,^\circ\text{C}$

Solution: The freezing point depression ΔT_f is calculated using the formula:

$$\Delta T_f = K_f \times m$$

Where: - ΔT_f is the freezing point depression, - $K_f = 1.86\,^\circ\text{C·kg/mol}$ is the freezing point depression constant, - m is the molality of the solution, which is given by:

$$m = \frac{\text{moles of solute}}{\text{mass of solvent in kg}} = \frac{0.5\,\text{mol}}{1\,\text{kg}} = 0.5\,\text{mol/kg}$$

Now calculate ΔT_f:

$$\Delta T_f = 1.86 \times 0.5 = 0.93\,^\circ\text{C}$$

Thus, the freezing point depression is $0.93\,^\circ\text{C}$.

Quick Tip

The freezing point depression depends on the molality of the solution. For non-volatile solutes, the freezing point of the solvent decreases by $\Delta T_f = K_f \times m$.

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14. The energy of the nth orbit of the hydrogen atom is given by:

$$E_n = -\frac{13.6}{n^2}\,\text{eV}$$

What is the energy of the second orbit (n = 2) of the hydrogen atom?

(1) $-3.4\,\text{eV}$

(2) $-13.6\,\text{eV}$

(3) $-6.8\,\text{eV}$

(4) $-1.36\,\text{eV}$

Correct Answer: (1) $-3.4\,\text{eV}$

Solution: We are given the energy of the nth orbit of the hydrogen atom by the equation:

$$E_n = -\frac{13.6}{n^2}\,\text{eV}$$

For the second orbit ($n = 2$):

$$E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4\,\text{eV}$$

Thus, the energy of the second orbit is $-3.4\,\text{eV}$.

Quick Tip

The energy of an electron in the hydrogen atom depends on the square of the principal quantum number n. The energy becomes less negative (closer to zero) as n increases.

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15. In the reaction:

$$\text{Zn(s)} + \text{CuSO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{Cu(s)}$$

Which of the following is the correct oxidation half-reaction?

(1) $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$

(2) $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$

(3) $\text{Zn}^{2+} + 2e^- \rightarrow \text{Zn}$

(4) $\text{Cu} \rightarrow \text{Cu}^{2+} + 2e^-$

Correct Answer: (1) $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$

Solution: In this redox reaction, zinc (Zn) is oxidized and copper ions (Cu^{2+}) are reduced. Oxidation involves the loss of electrons. Zinc is losing two electrons to form Zn^{2+}:

$$\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$$

Thus, the oxidation half-reaction is:

$$\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$$

Therefore, the correct oxidation half-reaction is option (1).

Quick Tip

In redox reactions, oxidation involves the loss of electrons, and reduction involves the gain of electrons. The oxidation half-reaction always shows the species losing electrons.

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16. Which of the following is the primary function of the human respiratory system?

(1) To transport oxygen to tissues and carbon dioxide to the lungs.

(2) To remove waste products from the body.

(3) To facilitate digestion and absorption of nutrients.

(4) To maintain homeostasis by regulating blood pH.

Correct Answer: (1) To transport oxygen to tissues and carbon dioxide to the lungs.

Solution: The primary function of the human respiratory system is to exchange gases, specifically oxygen and carbon dioxide. Oxygen is taken in from the atmosphere and transported to the tissues, while carbon dioxide, a waste product of cellular respiration, is carried from the tissues to the lungs to be exhaled.

- The respiratory system includes the nose, trachea, bronchi, and lungs, which facilitate gas exchange through alveoli.

Thus, the correct answer is that the respiratory system's primary function is to transport oxygen to tissues and carbon dioxide to the lungs.

Quick Tip

The respiratory system works in close collaboration with the circulatory system to transport gases. Oxygen is delivered to tissues, and carbon dioxide is removed through breathing.

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17. In a monohybrid cross between two heterozygous pea plants (Pp x Pp), what is the expected phenotypic ratio of the offspring?

(1) 3:1

(2) 1:2:1

(3) 1:1

(4) 4:0

Correct Answer: (1) 3:1

Solution: In a monohybrid cross between two heterozygous pea plants (Pp x Pp), the alleles segregate according to Mendelian inheritance. The possible genotypes of the offspring are:

- PP (homozygous dominant),
- Pp (heterozygous),
- pp (homozygous recessive).

By using a Punnett square, we can determine the genotypic and phenotypic ratios.

- The possible genotypes are:

- 1 PP : 2 Pp : 1 pp.

Since P (dominant) is responsible for the dominant phenotype and p (recessive) is responsible for the recessive phenotype, the phenotypic ratio is:

- 3 dominant (PP and Pp) : 1 recessive (pp).

Thus, the expected phenotypic ratio of the offspring is 3:1.

Quick Tip

A monohybrid cross between two heterozygous individuals typically produces a 3:1 phenotypic ratio, where the dominant allele masks the expression of the recessive allele.

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18. Which of the following is an example of a primary consumer in an ecosystem?

(1) Grasshopper

(2) Snake

(3) Fox

(4) Deer

Correct Answer: (1) Grasshopper

Solution: In an ecosystem, primary consumers are herbivores that feed directly on producers (plants).

- The grasshopper is an herbivore and feeds on plants, making it a primary consumer.

- A snake (Option 2) is a secondary or tertiary consumer since it eats other animals.

- A fox (Option 3) is a tertiary consumer and also eats animals, not plants.

- A deer (Option 4) is also a primary consumer, but the best option for this question, given that grasshopper is a clear example of a herbivore, is grasshopper.

Thus, the correct answer is the grasshopper.

Quick Tip

Primary consumers are the first organisms in the food chain that feed on producers (plants), while secondary and tertiary consumers are predators that feed on herbivores or other predators.

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19. Which part of the human brain is primarily responsible for regulating basic life functions, such as heart rate and breathing?

(1) Cerebrum

(2) Cerebellum

(3) Medulla Oblongata

(4) Hypothalamus

Correct Answer: (3) Medulla Oblongata

Solution: The medulla oblongata, located in the brainstem, plays a crucial role in regulating vital involuntary functions such as heart rate, breathing, blood pressure, and digestion. It is a part of the autonomic nervous system.

- The cerebrum (Option 1) is responsible for higher functions like thinking, memory, and voluntary movement.

- The cerebellum (Option 2) is involved in coordination and balance.

- The hypothalamus (Option 4) regulates temperature, hunger, and thirst, and controls the pituitary gland, but it does not control basic life functions like heart rate or breathing.

Thus, the correct answer is the medulla oblongata.

Quick Tip

The medulla oblongata is a vital part of the brain that controls autonomic functions necessary for life. Damage to this area can disrupt critical body functions.

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20. Which of the following is the correct equation for photosynthesis?

(1) $6CO_2 + 6H_2O +$ light energy $\rightarrow C_6H_{12}O_6 + 6O_2$

(2) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O +$ energy

(3) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 +$ light energy

(4) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O +$ light energy

Correct Answer: (1) $6CO_2 + 6H_2O +$ light energy $\rightarrow C_6H_{12}O_6 + 6O_2$

Solution: Photosynthesis is the process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water. The general equation for photosynthesis is:

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

In this process: - $6CO_2$ represents carbon dioxide, - $6H_2O$ represents water, - $C_6H_{12}O_6$ is glucose (a form of sugar), - $6O_2$ is oxygen produced as a by-product.
Thus, the correct equation is Option (1).

Quick Tip

Photosynthesis occurs in two stages: the light-dependent reactions, which use light energy to split water and generate ATP, and the Calvin cycle, which uses ATP to synthesize glucose from carbon dioxide.

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21. Which organelle is primarily responsible for producing ATP in a cell?

(1) Nucleus

(2) Mitochondria

(3) Endoplasmic Reticulum

(4) Golgi Apparatus

Correct Answer: (2) Mitochondria

Solution: The mitochondria are the ”powerhouses” of the cell. They are primarily responsible for the production of ATP (adenosine triphosphate), which is the cell’s main energy carrier.
- The nucleus (Option 1) contains genetic material but does not produce ATP.
- The endoplasmic reticulum (Option 3) is involved in protein and lipid synthesis but does not generate ATP.

- The Golgi apparatus (Option 4) is responsible for modifying, sorting, and packaging proteins, not ATP production.
Thus, the correct answer is the mitochondria, which generate ATP through cellular respiration.

Quick Tip

The mitochondria have an inner membrane where ATP synthesis occurs through a process known as oxidative phosphorylation, using energy from nutrients such as glucose.

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22. In a DNA molecule, which of the following base-pairings is correct?

(1) Adenine pairs with Cytosine.

(2) Thymine pairs with Guanine.

(3) Adenine pairs with Thymine.

(4) Cytosine pairs with Uracil.

Correct Answer: (3) Adenine pairs with Thymine.

Solution: In the DNA double helix, the base-pairing rules are governed by hydrogen bonds between nitrogenous bases. The correct base pairings in DNA are:
- Adenine (A) pairs with Thymine (T) through two hydrogen bonds.
- Guanine (G) pairs with Cytosine (C) through three hydrogen bonds.
Thus, the correct base pairing is Adenine pairs with Thymine, and Guanine pairs with Cytosine.
The incorrect options are:
- Option (1): Adenine does not pair with Cytosine. Instead, Adenine pairs with Thymine.
- Option (2): Thymine does not pair with Guanine. Instead, Thymine pairs with Adenine.
- Option (4): Cytosine does not pair with Uracil. Cytosine pairs with Guanine in DNA, whereas Uracil is found in RNA, where it pairs with Adenine.
Thus, the correct answer is Option (3).

Quick Tip

Remember the base pairing rules: In DNA, A pairs with T and G pairs with C. This is known as complementary base pairing and is fundamental to the structure of the DNA molecule.

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23. Which of the following processes occurs during the second meiotic division (Meiosis II)?

(1) Homologous chromosomes are separated.

(2) Sister chromatids are separated.

(3) DNA replication occurs.

(4) Crossing over occurs.

Correct Answer: (2) Sister chromatids are separated.

Solution: Meiosis consists of two successive divisions, Meiosis I and Meiosis II, each with distinct functions:

- Meiosis I is a reduction division where homologous chromosomes are separated, resulting in two haploid cells. This is where crossing over occurs, leading to genetic variation.

- Meiosis II is similar to mitosis, where the sister chromatids of each chromosome are separated into four haploid cells.

Let's break down the options: - Option (1): Homologous chromosomes are separated in Meiosis I, not Meiosis II. During Meiosis I, homologous chromosomes are divided between the two daughter cells.

- Option (2): Sister chromatids are separated in Meiosis II. This is the defining event of Meiosis II, where each haploid cell from Meiosis I undergoes another division to separate the sister chromatids, resulting in four haploid cells.

- Option (3): DNA replication occurs before Meiosis I (during the S phase of interphase), but no DNA replication occurs between Meiosis I and Meiosis II.

- Option (4): Crossing over occurs during Prophase I of Meiosis I, not Meiosis II. Crossing over is important for genetic variation and involves the exchange of genetic material between homologous chromosomes.

Thus, the correct answer is Option (2), as sister chromatids are separated during Meiosis II.

Quick Tip

In Meiosis II, just like mitosis, the sister chromatids of each chromosome are separated, resulting in four genetically unique haploid cells. It is important to distinguish between Meiosis I and II, as they perform different roles in the division of genetic material.

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24. Which of the following factors does NOT affect the rate of an enzyme-catalyzed reaction?

(1) Temperature

(2) pH

(3) Substrate concentration

(4) Color of the enzyme

Correct Answer: (4) Color of the enzyme

Solution: Enzyme activity is influenced by several factors, but the color of the enzyme is not one of them. Let's break down the factors that affect enzyme activity:

- Temperature (Option 1): The rate of enzyme-catalyzed reactions typically increases with temperature, up to a certain point. However, extreme temperatures can denature enzymes and reduce their activity.
- pH (Option 2): Each enzyme has an optimal pH range in which it functions best. Deviations from this range can affect the enzyme's structure and function, reducing the rate of reaction.
- Substrate concentration (Option 3): Increasing the substrate concentration typically increases the rate of the reaction, up to a point, as more substrate molecules collide with the enzyme. After a certain concentration, the enzyme becomes saturated, and the rate of reaction levels off.
- Color of the enzyme (Option 4): The color of the enzyme does not influence its activity. Enzymes function based on their structure and the conditions in which they operate, but the color is not related to their catalytic properties.

Thus, the correct answer is Option (4).

Quick Tip

Enzyme activity is affected by factors like temperature, pH, and substrate concentration, but not by the color of the enzyme. Be sure to focus on factors that impact the enzyme's active site and molecular structure.
