MHT CET 2024 Question Paper With Solutions (April 24 - Shift 2)

Time Allowed :3 Hour	**Maximum Marks :**150	**Total Questions :**150

General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question booklet contains **150 Multiple Choice Questions (MCQs)**.
2. **Section-A:** Physics & Chemistry - 50 Questions each and
   Section-B: Mathematics - 50 Questions.
3. Choice and sequence for attempting questions will be as per the convenience of the candidate.
4. Read each question carefully.
5. Determine the one correct answer out of the four available options given for each question.
6. Each question with correct response shall be awarded **one (1) mark**. There shall be no negative marking.
7. No mark shall be granted for marking two or more answers of the same question, scratching, or overwriting.
8. Duration of the paper is **3 Hours**.

1. Phenylketonuria is caused by:
(1) Tyrosine hydroxylase
(2) Phenylalanine hydroxylase (PAH)
(3) Methionine synthase
(4) Argininosuccinate lyase

Correct Answer: (2) Phenylalanine hydroxylase (PAH)
Solution:
Phenylketonuria (PKU) is a genetic disorder caused by a deficiency of the enzyme **phenylalanine hydroxylase (PAH)**. This enzyme is responsible for converting the amino acid phenylalanine into tyrosine. Without functional PAH:

- Phenylalanine accumulates in the body, leading to toxic levels.
- This causes severe intellectual disabilities, delayed development, and other neurological problems if untreated.

PKU is typically managed through a diet low in phenylalanine.

Quick Tip

Phenylketonuria is an autosomal recessive disorder detected through newborn screening. Early dietary management can prevent its adverse effects.

2. Arrange the meninges in order from outer to inner:
(1) Pia mater, Arachnoid, Dura mater
(2) Dura mater, Arachnoid, Pia mater
(3) Arachnoid, Pia mater, Dura mater
(4) Pia mater, Dura mater, Arachnoid

Correct Answer: (2) Dura mater, Arachnoid, Pia mater
Solution:
The meninges are the protective layers that surround the brain and spinal cord. They are arranged in the following order from outermost to innermost:

1. **Dura mater:** The thick, tough outermost layer that provides strong protection.
2. **Arachnoid mater:** The middle layer with a web-like structure.
3. **Pia mater:** The thin, delicate innermost layer that closely adheres to the surface of the brain and spinal cord.

This arrangement ensures proper protection and cushioning for the central nervous system.

Quick Tip

Remember the order of meninges using the acronym **DAP**: Dura mater, Arachnoid mater, Pia mater.

3. Which hormones stimulate the production of pancreatic juice and bicarbonate?
(1) Insulin and Glucagon
(2) Gastrin and Somatostatin
(3) Cholecystokinin (CCK) and Secretin
(4) Epinephrine and Norepinephrine

Correct Answer: (3) Cholecystokinin (CCK) and Secretin
Solution:
Two key hormones stimulate the production of pancreatic juice and bicarbonate:

1. **Cholecystokinin (CCK):** This hormone is released by the small intestine in response to the presence of fats and proteins. It stimulates the pancreas to secrete enzyme-rich pancreatic juice that aids in digestion.
2. **Secretin:** This hormone is released in response to acidic chyme entering the small intestine. It stimulates the pancreas to produce bicarbonate-rich pancreatic juice to neutralize the acid.

Together, these hormones ensure the proper breakdown of food in the digestive system.

Quick Tip

Cholecystokinin (CCK) is primarily responsible for enzyme secretion, while Secretin focuses on bicarbonate secretion to neutralize stomach acids.

4. Arrange the following menstrual phases in order:
(1) Follicular phase, Menstruation, Ovulation, Luteal phase
(2) Menstruation, Ovulation, Follicular phase, Luteal phase
(3) Menstruation, Follicular phase, Ovulation, Luteal phase
(4) Luteal phase, Ovulation, Follicular phase, Menstruation

Correct Answer: (3) Menstruation, Follicular phase, Ovulation, Luteal phase
Solution:
The menstrual cycle is divided into four distinct phases in the following order:

1. **Menstruation:** The shedding of the uterine lining (endometrium).
2. **Follicular phase:** The development of ovarian follicles stimulated by follicle-stimulating hormone (FSH).
3. **Ovulation:** The release of a mature egg from the ovary, triggered by a surge in luteinizing hormone (LH).
4. **Luteal phase:** The corpus luteum forms and secretes progesterone to prepare the uterus for possible implantation.

Thus, the correct order is **Menstruation, Follicular phase, Ovulation, Luteal phase**.

Quick Tip

The menstrual cycle phases are driven by hormonal changes. FSH and LH regulate the follicular phase and ovulation, while progesterone is dominant in the luteal phase.

5. The last electron acceptor in ETS (Electron Transport System) is:
(1) Oxygen (O_2)
(2) NADH
(3) FADH
(4) Carbon dioxide (CO_2)

Correct Answer: (1) Oxygen (O_2)
Solution:
In the Electron Transport System (ETS), oxygen (O_2) serves as the final electron acceptor. The process is as follows:

- Electrons are transferred through a series of complexes in the inner mitochondrial membrane.
- At the end of the chain, electrons combine with O_2 and protons (H^+) to form water (H_2O).
- This reaction maintains the proton gradient essential for ATP synthesis.

Thus, oxygen is crucial for the efficient production of ATP in aerobic respiration.

Quick Tip

The equation for the final step in ETS is:

$$4H^+ + 4e^- + O_2 \rightarrow 2H_2O.$$

This process is vital for maintaining the proton gradient for ATP synthesis.

6. Which of the following reverses the apical dominance?
(1) Auxin
(2) Cytokinin
(3) Gibberellin
(4) Abscisic acid

Correct Answer: (2) Cytokinin
Solution:
Apical dominance is the phenomenon where the apical bud inhibits the growth of lateral buds. It is primarily regulated by the hormone **auxin**, which is produced at the shoot tip. **Cytokinin**, however, acts in opposition to auxin and promotes the growth of lateral buds, thereby reversing apical dominance.

- Auxin maintains the dominance of the apical bud by suppressing the lateral bud growth.
- Cytokinin encourages cell division in the lateral buds, effectively overcoming the inhibitory effect of auxin.

Thus, the hormone that reverses apical dominance is **cytokinin**.

Quick Tip

Remember that auxin promotes apical dominance, while cytokinin reverses it by stimulating lateral bud growth.

7. From where does the female gametophyte not develop?
(1) Megaspore mother cell
(2) Nucellus
(3) Megaspore
(4) Microspore mother cell

Correct Answer: (4) Microspore mother cell
Solution:
The female gametophyte (also known as the embryo sac in angiosperms) develops from the following:

- **Megaspore mother cell:** Undergoes meiosis to produce megaspores, one of which develops into the female gametophyte.
- **Nucellus:** Provides nutrition to the developing female gametophyte.
- **Megaspore:** Directly develops into the female gametophyte through mitosis.

However, the **microspore mother cell** is responsible for producing microspores, which develop into the male gametophyte (pollen grains). It is not involved in the development of the female gametophyte.
Thus, the female gametophyte does not develop from the **microspore mother cell**.

Quick Tip

Remember that the female gametophyte develops from the megaspore mother cell, whereas the male gametophyte develops from the microspore mother cell.

8. Inorganic phosphate is involved in which step of respiration?
(1) Glycolysis
(2) Krebs cycle
(3) Electron Transport System (ETS)
(4) Fermentation

Correct Answer: (1) Glycolysis
Solution:
Inorganic phosphate (P_i) plays a crucial role in the process of **glycolysis**, particularly during the following steps:

1. **Step: Conversion of glyceraldehyde-3-phosphate (G3P) to 1,3-bisphosphoglycerate:** In this reaction, an inorganic phosphate (P_i) is added to G3P, catalyzed by the enzyme glyceraldehyde-3-phosphate dehydrogenase.
2. This step is essential for producing high-energy intermediates, which eventually lead to ATP generation.

Although inorganic phosphate is involved in other stages like the Krebs cycle and ETS indirectly, its direct involvement in adding to metabolic intermediates is specific to **glycolysis**.

Quick Tip

In glycolysis, inorganic phosphate (P_i) is crucial for generating high-energy intermediates, particularly in the energy payoff phase.

Physics

1. A vessel completely filled with water has holes A and B at depths h and $3h$ from the top, respectively. Hole A is a square of side L, and B is a circle of radius r. The water flowing out per second from both the holes is the same. Then L is equal to:
(1) $L = 2^{3/4}\pi^{1/2}r$
(2) $L = 3^{1/4}\pi^{1/2}r$
(3) $L = 4^{1/2}\pi^{1/2}r$
(4) $L = 3^{1/2}\pi^{1/2}r$

Correct Answer: (2) $L = 3^{1/4}\pi^{1/2}r$
Solution:

Step 1: Apply Torricelli's theorem for efflux velocity.
The velocity of efflux for a hole at depth h is given by:

$$v = \sqrt{2gh},$$

where g is the acceleration due to gravity.
For hole A at depth h:

$$v_A = \sqrt{2gh}.$$

For hole B at depth $3h$:

$$v_B = \sqrt{2g(3h)} = \sqrt{6gh}.$$

Step 2: Relating the flow rates.
The rate of flow (Q) is given by:

$$Q = \text{Area} \times \text{Velocity}.$$

For hole A (square of side L):

$$Q_A = L^2 \cdot v_A = L^2 \cdot \sqrt{2gh}.$$

For hole B (circle of radius r):

$$Q_B = \pi r^2 \cdot v_B = \pi r^2 \cdot \sqrt{6gh}.$$

Given that the flow rates are equal ($Q_A = Q_B$):

$$L^2 \cdot \sqrt{2gh} = \pi r^2 \cdot \sqrt{6gh}.$$

Step 3: Simplify the equation.
Cancel $\sqrt{gh}$ from both sides:

$$L^2 \cdot \sqrt{2} = \pi r^2 \cdot \sqrt{6}.$$

Divide both sides by $\sqrt{2}$:

$$L^2 = \pi r^2 \cdot \sqrt{\frac{6}{2}} = \pi r^2 \cdot \sqrt{3}.$$

Take the square root of both sides:

$$L = \sqrt{\pi r^2 \cdot \sqrt{3}} = r \cdot \pi^{1/2} \cdot (3^{1/4}).$$

Thus, $L = 3^{1/4}\pi^{1/2}r$.

> Quick Tip
>
> Use Torricelli's theorem $v = \sqrt{2gh}$ to calculate efflux velocity and combine it with the area of the hole to equate flow rates.

2. A cylinder of fixed capacity 67.2 L contains helium gas at STP. The amount of heat needed to raise the temperature of the gas in the cylinder by 20°C is:
(1) 700.5 J
(2) 747.9 J
(3) 760.2 J
(4) 800.0 J

Correct Answer: (2) 747.9 J
Solution:
Step 1: Recall the formula for heat capacity at constant volume.
The heat required to raise the temperature of a gas is given by:

$$Q = nC_v\Delta T,$$

where:

- n is the number of moles of gas,
- C_v is the molar heat capacity at constant volume for helium,
- ΔT is the temperature change.

Step 2: Calculate the number of moles.
At STP (Standard Temperature and Pressure), the molar volume of an ideal gas is 22.4 L. The number of moles is:

$$n = \frac{\text{Volume of gas}}{\text{Molar volume}} = \frac{67.2}{22.4} = 3.0\,\text{mol}.$$

Step 3: Substitute the known values.
For helium, $C_v = \frac{3}{2}R$, where $R = 8.314\,\text{J/mol K}$:

$$C_v = \frac{3}{2} \times 8.314 = 12.471\,\text{J/mol K}.$$

The temperature change is $\Delta T = 20\,\text{K}$.
Substitute these into the formula:

$$Q = nC_v\Delta T = 3.0 \times 12.471 \times 20.$$

Step 4: Calculate the result.

$$Q = 3.0 \times 249.42 = 747.9\,\text{J}.$$

Thus, the heat required is 747.9 J.

Quick Tip

For monatomic gases like helium, $C_v = \frac{3}{2}R$ and $C_p = \frac{5}{2}R$. Use $Q = nC_v\Delta T$ for calculations at constant volume.

Chemistry

1. Arrange the affinity of hemoglobin (Hb) towards CO, CO_2, and O_2 in increasing order.
(1) $O_2 > CO_2 > CO$
(2) $CO_2 > O_2 > CO$
(3) $O_2 > CO > CO_2$
(4) $CO > CO_2 > O_2$

Correct Answer: (4) $CO > CO_2 > O_2$
Solution:
The affinity of hemoglobin (Hb) for different gases is determined by their chemical interactions with the heme group. Here is the order of affinity:

- **Carbon monoxide (CO):** Hemoglobin has the highest affinity for CO, which is about 200-300 times greater than its affinity for O_2. This strong binding significantly reduces oxygen transport when CO is present.
- **Carbon dioxide (CO_2):** Hemoglobin binds CO_2 to form carbaminohemoglobin, but the affinity is much lower compared to CO.
- **Oxygen (O_2):** Hemoglobin has a lower affinity for O_2 compared to CO_2 and CO.

Thus, the order of affinity is:

$$CO > CO_2 > O_2.$$

Quick Tip

Remember that carbon monoxide (CO) forms a stable complex with hemoglobin, leading to carbon monoxide poisoning. Oxygen therapy is used to displace CO from hemoglobin.

2. Boron has two isotopes with atomic masses 10 and 11. If its average atomic mass is 10.81, the abundance of the lighter isotope is:
(1) 19%
(2) 20%
(3) 25%
(4) 10%

Correct Answer: (1) 19%
Solution:
Let the percentage abundance of the lighter isotope (^{10}B) be x%. Then the percentage abundance of the heavier isotope (^{11}B) will be $(100 - x)$%.
The average atomic mass of boron is given by:

$$\text{Average atomic mass} = \frac{(x \cdot 10) + ((100 - x) \cdot 11)}{100}.$$

Substitute the given average atomic mass 10.81:

$$10.81 = \frac{(x \cdot 10) + ((100 - x) \cdot 11)}{100}.$$

Simplify:

$$10.81 = \frac{10x + 1100 - 11x}{100}.$$

Combine like terms:

$$10.81 = \frac{1100 - x}{100}.$$

Multiply through by 100:

$$1081 = 1100 - x.$$

Solve for x:

$$x = 1100 - 1081 = 19.$$

Thus, the abundance of the lighter isotope is **19**%.

Quick Tip

For isotopic abundance problems, use the formula:

$$\text{Average mass} = \frac{(\text{Mass of isotope 1}) \times (\text{abundance}) + (\text{Mass of isotope 2}) \times (\text{abundance})}{100}.$$

Simplify step-by-step for accurate results.