MHT CET 2023 May 19 Shift 2 Question Paper with Solutions

Time Allowed :3 Hours	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. What is the diameter of a Malpighian body in micrometers?

Correct Answer: Approximately 150-250 micrometers (μm) in humans.

Solution:

Step 1: Understanding the Question:
The question asks for the typical diameter of a Malpighian body, also known as a renal corpuscle, expressed in micrometers (μm).

Step 2: Key Concepts:

- **Malpighian Body (Renal Corpuscle):** This is the initial blood-filtering component of a nephron in the kidney. It consists of two parts: the glomerulus (a tuft of capillaries) and Bowman's capsule (a double-walled cup-like structure that surrounds the glomerulus).

- **Function:** Its primary role is to filter blood plasma to produce glomerular filtrate, which then passes into the rest of the nephron to be processed into urine.

Step 3: Detailed Explanation:
The size of the Malpighian body can vary depending on the species and the individual's health and age. In humans, the average diameter of this structure is typically in the range of 150 to 250 micrometers (μm).
This small size allows for a vast number of these filtering units (nephrons) to be packed into each kidney, maximizing the surface area available for blood filtration. Each human kidney contains approximately one million nephrons.

Step 4: Final Answer:
The average diameter of a human Malpighian body is about 150-250 μm.

Quick Tip

Remember the synonyms for Malpighian body: renal corpuscle. It's the "filtering unit" of the nephron, consisting of the glomerulus and Bowman's capsule. Associate it with the very first step of urine formation.

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2. What is the location of the anticodon?

Correct Answer: On the anticodon loop of a transfer RNA (tRNA) molecule.

Solution:

Step 1: Understanding the Question:
The question asks to identify the specific location of an anticodon within a cell or molecule.

Step 2: Key Concepts:

- **Translation:** The process of protein synthesis where the genetic information encoded in messenger RNA (mRNA) is used to create a specific sequence of amino acids in a polypeptide chain.
- **mRNA (Messenger RNA):** Carries the genetic code from DNA in the form of codons (sequences of three nucleotides).
- **tRNA (Transfer RNA):** Acts as an adapter molecule. It carries a specific amino acid at one end and has an anticodon at the other end.
- **Anticodon:** A sequence of three nucleotides that is complementary to a specific codon on the mRNA strand.

Step 3: Detailed Explanation:
The anticodon is a crucial part of the transfer RNA (tRNA) molecule. The tRNA molecule has a characteristic cloverleaf secondary structure. One of the loops of this structure is called the **anticodon loop**.
The anticodon itself is the sequence of three bases located at the tip of this loop.
During translation, the ribosome moves along the mRNA molecule. As each mRNA codon is presented, the specific tRNA molecule with the complementary anticodon binds to it. This codon-anticodon pairing ensures that the correct amino acid (which the tRNA is carrying) is added to the growing polypeptide chain.

Step 4: Final Answer:
The anticodon is located on the anticodon loop of a tRNA molecule.

Quick Tip

Remember the roles in protein synthesis: mRNA is the 'message' with codons, tRNA is the 'translator' with anticodons that brings the right amino acid, and rRNA (in ribosomes) is the 'factory' where the process happens. The anticodon on tRNA reads the codon on mRNA.

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3. What are the principles of green chemistry?

Correct Answer: A set of 12 principles aimed at making chemical processes and products more environmentally sustainable and safer.

Solution:

Step 1: Understanding the Question:
The question asks for the principles of green chemistry. This is a framework designed to guide chemists in creating more sustainable chemical processes.

Step 2: Detailed Explanation:
Green chemistry, also known as sustainable chemistry, is a philosophy of chemical research and engineering that encourages the design of products and processes that minimize the use and generation of hazardous substances. The 12 principles, developed by Paul Anastas and John Warner, are:

1. **Prevention:** It is better to prevent waste than to treat or clean up waste after it has been created.

2. **Atom Economy:** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3. **Less Hazardous Chemical Syntheses:** Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. **Designing Safer Chemicals:** Chemical products should be designed to affect their desired function while minimizing their toxicity.

5. **Safer Solvents and Auxiliaries:** The use of auxiliary substances (e.g., solvents, separation agents) should be made unnecessary or innocuous wherever possible.

6. **Design for Energy Efficiency:** Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

7. **Use of Renewable Feedstocks:** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8. **Reduce Derivatives:** Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. **Catalysis:** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. **Design for Degradation:** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. **Real-time Analysis for Pollution Prevention:** Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. **Inherently Safer Chemistry for Accident Prevention:** Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Step 3: Final Answer:
The principles of green chemistry are a set of 12 guiding tenets that focus on waste prevention, atom economy, use of safer substances, energy efficiency, and overall sustainability in the chemical industry.

> Quick Tip
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> For exams, you don't always need to memorize all 12 principles verbatim, but you should understand the core ideas: Prevent Waste, Maximize Atom Efficiency, Use Safer Chemicals, and Save Energy. These are the most commonly tested concepts.

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4. What is the SI unit of the rate of diffusion?

Correct Answer: The SI unit for the diffusion coefficient (D) is m^2/s. The rate of diffusion (flux) is $mol \cdot m^{-2} \cdot s^{-1}$.

Solution:

Step 1: Understanding the Question:
The question asks for the SI unit for the "rate of diffusion". This term can be ambiguous. It can refer to:

- **Diffusion flux (J):** The amount of substance diffusing across a unit area per unit time. This is a true "rate".
- **Diffusion coefficient (D):** A proportionality constant that measures how quickly a substance diffuses through a medium. It is a property of the substance and the medium.

Given the answer provided in the source material (m^2/s), the question is most likely referring to the **diffusion coefficient**.

Step 2: Key Formula or Approach:
We use Fick's first law of diffusion, which relates the diffusion flux (J) to the concentration gradient ($\frac{dC}{dx}$) and the diffusion coefficient (D).

$$J = -D\frac{dC}{dx}$$

Step 3: Detailed Explanation:
Let's analyze the units from Fick's Law to derive the unit for D.

- **Flux (J):** Amount of substance / (Area $\times$ Time). SI unit: $\frac{mol}{m^2 \cdot s}$.
- **Concentration (C):** Amount of substance / Volume. SI unit: $\frac{mol}{m^3}$.
- **Distance (x):** SI unit: m.
- **Concentration Gradient ($\frac{dC}{dx}$):** Unit of Concentration / Unit of Distance. SI unit: $\frac{mol/m^3}{m} = \frac{mol}{m^4}$.

Now, rearrange Fick's Law to solve for D:

$$D = -J/\left(\frac{dC}{dx}\right)$$

Let's find the units of D:

$$\text{Unit of D} = \frac{\text{Unit of J}}{\text{Unit of dC/dx}} = \frac{\text{mol}/(\text{m}^2 \cdot \text{s})}{\text{mol}/\text{m}^4}$$

$$\text{Unit of D} = \frac{\text{mol}}{\text{m}^2 \cdot \text{s}} \times \frac{\text{m}^4}{\text{mol}} = \frac{\text{m}^2}{\text{s}}$$

Thus, the SI unit of the diffusion coefficient is square meters per second (m^2/s).

Step 4: Final Answer:
The SI unit for the diffusion coefficient, often referred to as the rate of diffusion in a simplified context, is m^2/s.

> Quick Tip
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> Be careful with the term "rate of diffusion." In physics and chemistry, a 'rate' usually implies 'per unit time'. Diffusion coefficient (m^2/s) is a measure of mobility, while diffusion flux ($\text{mol}/\text{m}^2/\text{s}$) is the actual rate of transport per unit area. For most exam questions, if you see diffusion, they are likely asking for the unit of the coefficient, D.

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5. What causes poisoning by Carbon Monoxide?

Correct Answer: Inhalation of carbon monoxide (CO) gas, which binds strongly to hemoglobin and prevents oxygen transport in the blood.

Solution:

Step 1: Understanding the Question:
The question asks for the cause and mechanism of carbon monoxide (CO) poisoning.

Step 2: Key Concepts:

- **Carbon Monoxide (CO):** A colorless, odorless, tasteless gas produced from the incomplete combustion of carbon-containing fuels (like wood, gasoline, natural gas, coal).
- **Hemoglobin (Hb):** The protein in red blood cells responsible for transporting oxygen from the lungs to the body's tissues.
- **Affinity:** The degree to which a substance tends to combine with another.

Step 3: Detailed Explanation:
The primary cause of carbon monoxide poisoning is the inhalation of the gas. The poisoning occurs due to a process called competitive binding.

1. Normally, oxygen (O_2) from the lungs binds to the iron atom in the heme group of hemoglobin to form oxyhemoglobin (HbO_2), which then travels through the bloodstream to release oxygen to the cells.

2. When carbon monoxide is inhaled, it also enters the bloodstream and competes with oxygen to bind to the same site on hemoglobin.

3. The critical issue is that hemoglobin's affinity for carbon monoxide is about **200-250 times stronger** than its affinity for oxygen.

4. Because of this high affinity, even at low concentrations, CO will preferentially bind to hemoglobin, forming a very stable compound called **carboxyhemoglobin (COHb)**.

5. The formation of COHb has two dangerous effects:

   - It reduces the number of hemoglobin molecules available to carry oxygen.

   - It also causes the remaining oxyhemoglobin to bind oxygen more tightly, making it harder for the oxygen to be released to the tissues.

6. This leads to severe oxygen deprivation (hypoxia) in the body's tissues and organs, particularly affecting the brain and heart, which have high oxygen demands. This cellular oxygen starvation is what causes the symptoms of poisoning and can lead to permanent organ damage or death.

Step 4: Final Answer:
Carbon monoxide poisoning is caused by inhaling CO gas, which binds to hemoglobin with an affinity much higher than oxygen, forming carboxyhemoglobin. This drastically reduces the blood's ability to transport oxygen to tissues, leading to cellular hypoxia.

Quick Tip

The key to understanding CO poisoning is its high affinity for hemoglobin. Remember the number: CO binds about 200 times more strongly than O_2. This explains why even small amounts of CO in the air can be extremely dangerous.

6. What are the characteristics of capillaries?

Correct Answer: Capillaries are microscopic blood vessels with thin walls, a vast total surface area, and slow blood flow, all of which are features that facilitate the efficient exchange of substances between blood and tissues.

Solution:

Step 1: Understanding the Question:
The question asks for the main characteristics of capillaries, which are the smallest blood vessels in the circulatory system.

Step 2: Detailed Explanation:
Capillaries have several distinct characteristics that are perfectly suited for their primary function: the exchange of gases, nutrients, and waste products between the blood and the surrounding body tissues.

- **Microscopic Size:** Capillaries are extremely narrow, with a diameter of about 5-10 micrometers (μm), which is often just wide enough for red blood cells to pass through in single file.

- **Thin Walls:** Their walls consist of a single layer of endothelial cells (a type of epithelium) and a thin basement membrane. This single-cell thickness provides a very short diffusion distance, allowing for rapid and efficient exchange of substances.

- **High Permeability:** The endothelial cells that form the capillary walls have small gaps or pores (fenestrations in some types) between them, which makes the walls highly permeable to water, ions, gases, and small molecules like glucose and amino acids.

- **Extensive Network (Capillary Beds):** Capillaries do not exist in isolation but form vast, interconnected networks called capillary beds. This branching network permeates nearly every tissue in the body, ensuring that no cell is far from a blood supply.

- **Large Total Cross-Sectional Area:** Although each capillary is tiny, their immense number means that the total cross-sectional area of all capillaries combined is much larger than that of the arteries or veins.

- **Slow Blood Flow:** Due to the large total cross-sectional area, the velocity of blood flow is slowest in the capillaries. This slow flow provides sufficient time (transit time) for diffusion and exchange of substances to occur between the blood and the tissues.

Step 3: Final Answer:
The key characteristics of capillaries are their microscopic diameter, extremely thin walls (one

cell thick), high permeability, formation of extensive networks, large total surface area, and the slow velocity of blood flowing through them.

Quick Tip

Think of capillaries with the acronym **STEPS**: **S**low flow, **T**hin walls, **E**xchange function, **P**ermeable, **S**mall diameter. These features are all interconnected to maximize their primary role of substance exchange.
