GATE 2026 Biomedical Engineering Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :100	Total Questions :65

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Each GATE 2024 paper consists of a total of 100 marks. The examination is divided into two sections – General Aptitude (GA) and the Candidate's Selected Subjects. General Aptitude carries 15 marks, while the remaining 85 marks are dedicated to the candidate's chosen test paper syllabus.
2. GATE 2024 will be conducted in English as a Computer Based Test (CBT) at select centres in select cities. The duration of the examination is 3 hours.
3. MCQs carry 1 mark or 2 marks.
4. For a wrong answer in a 1-mark MCQ, 1/3 mark is deducted.
5. For a wrong answer in a 2-mark MCQ, 2/3 mark is deducted.
6. No negative marking for wrong answers in MSQ or NAT questions.

1. In the human pancreas, which cell types secrete insulin and glucagon?

(A) Alpha cells and delta cells, respectively
(B) Beta cells and delta cells, respectively
(C) Alpha cells and beta cells, respectively
(D) Beta cells and alpha cells, respectively

Correct Answer: (D) Beta cells and alpha cells, respectively

Solution:

Step 1: Understanding the Question:
The question asks to identify the specific cells in the human pancreas responsible for secreting the hormones insulin and glucagon, in that respective order.

Step 2: Detailed Explanation:
The pancreas contains clusters of endocrine cells called the Islets of Langerhans. These islets contain several types of cells, each responsible for producing a specific hormone that regulates blood sugar levels.

- **Beta (β) cells:** These are the most abundant cells in the islets. They produce and secrete **insulin**. Insulin lowers blood glucose levels by promoting the uptake of glucose by cells and the storage of glucose as glycogen in the liver and muscles.

- **Alpha (α) cells:** These cells produce and secrete **glucagon**. Glucagon has the opposite effect of insulin; it raises blood glucose levels by stimulating the liver to break down glycogen (glycogenolysis) and synthesize glucose from other sources (gluconeogenesis).

- **Delta (δ) cells:** These cells secrete somatostatin, a hormone that inhibits the release of both insulin and glucagon.

The question asks for the cells that secrete insulin and glucagon, respectively. Therefore, the correct answer is Beta cells and Alpha cells.

Step 3: Final Answer:
Insulin is secreted by Beta cells, and glucagon is secreted by Alpha cells.

> Quick Tip
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> Use a mnemonic to remember: **I**nsulin comes from **B**eta cells. **G**lucagon comes from **A**lpha cells (think "A" for "adds" sugar to blood).

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2. At time t, the cardiac dipole is oriented at - 45° (minus forty five degrees) to the horizontal axis. The magnitude of the dipole is 3 mV. Assuming Einthoven frontal plane configuration, what is the magnitude (in mV) of the electrical signal in lead II? (Round off the answer to two decimal places.)

Correct Answer: 0.78

Solution:

Step 1: Understanding the Question:
We are given the magnitude and direction (angle) of the heart's electrical vector (cardiac dipole). We need to find the magnitude of the voltage that would be measured by Lead II in the Einthoven's triangle configuration.

Step 2: Key Formula or Approach:
The voltage measured by any lead in the Einthoven configuration is the projection of the cardiac vector onto the axis of that lead. The formula is:

$$V_{\text{lead}} = V_{\text{dipole}} \times \cos(\theta)$$

where θ is the angle between the cardiac dipole vector and the lead axis.

Step 3: Detailed Explanation:
The standard angles for the Einthoven leads are:

- Lead I axis: 0°

- Lead II axis: $+60°$
- Lead III axis: $+120°$

We are given:

- Magnitude of the cardiac dipole, $V_{\text{dipole}} = 3$ mV
- Angle of the cardiac dipole, $\theta_{\text{dipole}} = -45°$

The lead we are interested in is Lead II, which has an angle $\theta_{\text{lead II}} = +60°$.

The angle θ between the dipole vector and the Lead II axis is the difference between their angles:

$$\theta = \theta_{\text{lead II}} - \theta_{\text{dipole}} = 60° - (-45°) = 105°$$

Now, we can calculate the voltage in Lead II:

$$V_{\text{lead II}} = 3 \times \cos(105°)$$

We know that $\cos(105°) = \cos(60° + 45°) = \cos(60°)\cos(45°) - \sin(60°)\sin(45°)$.
Using standard trigonometric values:

$$\cos(105°) = \left(\frac{1}{2}\right)\left(\frac{\sqrt{2}}{2}\right) - \left(\frac{\sqrt{3}}{2}\right)\left(\frac{\sqrt{2}}{2}\right) = \frac{\sqrt{2}-\sqrt{6}}{4} \approx -0.2588$$

So, the voltage is:

$$V_{\text{lead II}} = 3 \times (-0.2588) \approx -0.7764 \text{ mV}$$

The question asks for the **magnitude** of the electrical signal.

$$|V_{\text{lead II}}| = |-0.7764| \approx 0.7764 \text{ mV}$$

Rounding off to two decimal places, we get 0.78 mV.

Step 4: Final Answer:
The magnitude of the electrical signal in lead II is 0.78 mV.

Quick Tip

Always remember the standard angles for Einthoven's leads (I: 0°, II: 60°, III: 120°). The measured voltage is always the dipole magnitude multiplied by the cosine of the angle *between* the dipole vector and the lead axis.

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3. For a tissue with Young's modulus 4 kPa and shear modulus 1.5 kPa, what is the value of the Poisson's ratio?

(A) $\frac{1}{4}$
(B) $\frac{1}{5}$
(C) $\frac{1}{2}$

(D) $\frac{1}{3}$

Correct Answer: (D) $\frac{1}{3}$

Solution:

Step 1: Understanding the Question:
The problem provides the Young's modulus (E) and the shear modulus (G) for a material (tissue) and asks to calculate its Poisson's ratio (ν).

Step 2: Key Formula or Approach:
For an isotropic elastic material, the relationship between Young's modulus (E), shear modulus (G), and Poisson's ratio (ν) is given by the formula:

$$E = 2G(1 + \nu)$$

Step 3: Detailed Explanation:
We are given the following values:

- Young's modulus, $E = 4$ kPa
- Shear modulus, $G = 1.5$ kPa

We substitute these values into the formula:

$$4 = 2 \times 1.5 \times (1 + \nu)$$

$$4 = 3 \times (1 + \nu)$$

Now, we solve for ν:

$$\frac{4}{3} = 1 + \nu$$

$$\nu = \frac{4}{3} - 1$$

$$\nu = \frac{4-3}{3}$$

$$\nu = \frac{1}{3}$$

Step 4: Final Answer:
The value of the Poisson's ratio is $\frac{1}{3}$.

> **Quick Tip**
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> Memorize the key relationships between elastic moduli for isotropic materials: $E = 2G(1 + \nu)$ and $E = 3K(1 - 2\nu)$, where K is the bulk modulus.

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4. Consider two cuboidal blocks of volume 1 cm^3 each, one made of gold and the other of undoped silicon. What will happen to the resistivity of these blocks if the

temperature is increased from 300 K to 350 K? Choose one of the following.

(A) Resistivity of gold increases and undoped silicon decreases
(B) Resistivity of gold decreases and undoped silicon increases
(C) Resistivity of gold remains same and undoped silicon increases
(D) Resistivity of gold decreases and undoped silicon remains same

Correct Answer: (A) Resistivity of gold increases and undoped silicon decreases

Solution:

Step 1: Understanding the Question:
The question asks about the effect of increasing temperature on the electrical resistivity of a metal (gold) and an intrinsic semiconductor (undoped silicon).

Step 2: Detailed Explanation:
The behavior of resistivity with temperature is fundamentally different for metals and semiconductors due to their different charge carrier mechanisms.

- **Gold (a Metal):** In metals, the concentration of free electrons (charge carriers) is very high and does not change significantly with temperature. Conduction is limited by the scattering of these electrons. As temperature increases, the metal ions in the lattice vibrate more intensely. These increased lattice vibrations (phonons) scatter the moving electrons more frequently, impeding their flow. This increased scattering leads to an **increase in resistivity**.

- **Undoped Silicon (a Semiconductor):** In an intrinsic semiconductor, the number of charge carriers (electrons in the conduction band and holes in the valence band) is relatively low at room temperature. As temperature increases, thermal energy excites more electrons from the valence band across the band gap to the conduction band. This process creates more electron-hole pairs, significantly **increasing the concentration of charge carriers**. This increase in carrier density is the dominant effect and outweighs the increased scattering effect. A higher number of charge carriers leads to better conductivity, which means the **resistivity decreases**.

Step 3: Final Answer:
Therefore, as the temperature increases, the resistivity of gold will increase, and the resistivity of undoped silicon will decrease.

Quick Tip

A simple rule to remember: For metals, Temperature $\uparrow \implies$ Resistivity $\uparrow$. For semiconductors, Temperature $\uparrow \implies$ Resistivity $\downarrow$.

5. Cerebrospinal fluid in humans is present in the _______________ space.

(A) subdural
(B) subarachnoid
(C) epidural
(D) pericardial

Correct Answer: (B) subarachnoid

Solution:

Step 1: Understanding the Question:
The question asks to identify the specific anatomical space where cerebrospinal fluid (CSF) is located.

Step 2: Detailed Explanation:
The brain and spinal cord are protected by three layers of membranes called the meninges. From the outermost layer to the innermost, they are:

1. **Dura Mater:** The tough, outermost layer.
2. **Arachnoid Mater:** The middle layer, named for its spiderweb-like appearance.
3. **Pia Mater:** The delicate innermost layer that adheres closely to the surface of the brain and spinal cord.

The spaces associated with these layers are:

- **Epidural space:** A potential space between the skull and the dura mater.
- **Subdural space:** A potential space between the dura mater and the arachnoid mater.
- **Subarachnoid space:** This is the actual space located between the arachnoid mater and the pia mater. It is filled with **cerebrospinal fluid (CSF)**, which acts as a cushion for the brain, provides nutrients, and removes waste products.
- **Pericardial space:** This is the space within the pericardium, the sac that surrounds the heart. It contains pericardial fluid, not CSF.

Step 3: Final Answer:
Based on the anatomical structure of the meninges, the cerebrospinal fluid is present in the subarachnoid space.

Quick Tip

Remember the order of the meninges from outside in: Dura, Arachnoid, Pia (DAP). CSF flows in the "subarachnoid" space, which is below the arachnoid layer.