CUET PG 2026 Nanoelectronics Question Paper with Solutions

Time Allowed :1 Hour 30 Minutes	**Maximum Marks :**300	**Total Questions :**75

General Instructions

Read the following instructions very carefully and strictly follow them:

- The Question Paper consists of 75 Multiple Choice Questions (MCQs).
- Total marks for the exam is 300.
- The total duration is 90 minutes; a, timer on the screen will display the remaining time, and the exam will automatically submit when the time reaches zero.
- For every correct answer, 4 marks (+4) will be awarded to the candidate, and a 1 mark (-1) will be deducted for every incorrect answer.
- Question papers are available in both English and Hindi.

1. Which allotrope of carbon is considered a one-dimensional (1D) nanostructure?
(A) Graphene
(B) Carbon Nanotube
(C) Fullerene
(D) Diamond

Correct Answer: (B) Carbon Nanotube

Solution:

Understanding the Question: The question asks us to identify the carbon allotrope that is classified as a 1D nanostructure based on how its dimensions are scaled.

Key Formulas and approach: Nanostructures are classified by the number of dimensions that are NOT at the nanoscale:

- 0D: All dimensions are at the nanoscale (e.g., Quantum Dots).
- 1D: One dimension is macroscopic/long, while two are at the nanoscale (e.g., Nanowires/Nanotubes).
- 2D: Two dimensions are macroscopic/long, while one is at the nanoscale (e.g., Nanosheets).

Detailed Solution:
Step 1: Analyzing Carbon Nanotubes. Carbon nanotubes are hollow cylinders made of carbon. While they can be very long (micro-scale or more), their diameter is in the nanometer range. This means electrons are primarily free to move in only one direction (along the axis).
Step 2: Evaluating other options. Graphene is a single-atom-thick sheet (2D). Fullerene is a spherical "buckyball" where all dimensions are tiny (0D). Diamond is a crystal that extends in three dimensions (3D).
Conclusion: Thus, the Carbon Nanotube is categorized as a 1D nanostructure.

Quick Tip

Think of the geometry: Point = 0D (Fullerene), Tube = 1D (CNT), Sheet = 2D (Graphene), Block = 3D (Diamond).

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2. How does the band gap of a semiconducting chiral carbon nanotube change as its diameter increases?
(A) The band gap increases
(B) The band gap decreases
(C) The band gap remains constant
(D) The band gap becomes zero

Correct Answer: (B) The band gap decreases

Solution:

Understanding the Question: We need to determine the mathematical relationship between the physical size (diameter) of a semiconducting CNT and its electronic band gap.

Key Formulas and approach: The band gap (E_g) of a semiconducting CNT is inversely proportional to its diameter (d). The general relation is:

$$E_g \propto \frac{1}{d}$$

Detailed Solution:
Step 1: Applying the inverse relationship. Based on the formula $E_g \approx 1/d$, we can see that the energy gap is dependent on the curvature of the tube.
Step 2: Analyzing the effect of increasing diameter. When the diameter d increases, the value of the fraction $1/d$ becomes smaller. Consequently, the band gap E_g must decrease.
Step 3: Physical Interpretation. As a nanotube gets wider, it becomes less curved and starts to resemble a flat graphene sheet. Since graphene has no band gap, the wider the tube, the smaller the gap becomes.
Conclusion: Therefore, an increase in diameter leads to a decrease in the band gap.

Quick Tip

Larger Nanotube Diameter $\rightarrow$ Lower Curvature $\rightarrow$ Smaller Band Gap ($E_g \approx 1/d$).

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3. What is the typical characteristic length scale range for nanomaterials?
(A) 1–100 nm
(B) 1–1000 nm
(C) 100–1000 nm
(D) 0.1–10 mm

Correct Answer: (A) 1–100 nm

Solution:

Understanding the Question: The question asks for the officially recognized size range that defines a material as a "nanomaterial."

Key Formulas and approach: Nanotechnology generally deals with structures where at least one dimension is measured in nanometers (10^{-9} m). The standard definition is based on the range where quantum effects start to dominate.

Detailed Solution:
Step 1: Defining the Nanoscale. Scientific organizations like ISO and the NNI define the nanoscale as the range from 1 nm up to 100 nm.
Step 2: Identifying the transition point. At scales larger than 100 nm, materials usually exhibit "bulk" properties. Below 100 nm, surface-to-volume ratios become extremely high, changing the material's behavior.
Conclusion: The characteristic range for nanomaterials is 1–100 nm.

> Quick Tip
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> Nanotechnology = Scale of 1 to 100 nm. This is roughly the size of a virus or small protein.

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4. In quantum mechanics, what is the degree of confinement for a Quantum Dot?
(A) One-dimensional confinement
(B) Two-dimensional confinement
(C) Three-dimensional confinement
(D) No confinement

Correct Answer: (C) Three-dimensional confinement

Solution:

Understanding the Question: We need to identify how many spatial dimensions restrict the movement of an electron within a Quantum Dot.

Key Formulas and approach: Confinement occurs in any dimension that is reduced to the nanometer scale.

- Quantum Well (2D sheet): 1D confinement.
- Quantum Wire (1D line): 2D confinement.
- Quantum Dot (0D point): 3D confinement.

Detailed Solution:
Step 1: Analyzing the structure. A Quantum Dot is a nanoparticle where all three dimensions (x, y, and z) are at the nanoscale.

Step 2: Identifying electron restriction. Because the particle is tiny in all directions, the electron has no "free" direction to move in. It is trapped in a 3D box.
Step 3: Quantum results. This total confinement leads to discrete energy levels, causing the dot to act like an "artificial atom."
Conclusion: A Quantum Dot exhibits three-dimensional confinement.

> Quick Tip
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> Quantum Dot = 0D material = 3D Confinement. The number of confinement dimensions + the object's dimensions = 3.

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5. What is the standard wavelength used in Extreme Ultraviolet (EUV) lithography?
(A) 248 nm
(B) 193 nm
(C) 13.5 nm
(D) 365 nm

Correct Answer: (C) 13.5 nm

Solution:

Understanding the Question: The question asks for the specific wavelength of light used in modern EUV lithography systems to print nanoscale features on silicon.

Key Formulas and approach: Resolution in lithography is limited by the wavelength of light (λ). To print smaller transistors, the industry must use shorter wavelengths.

Detailed Solution:
Step 1: The shift to EUV. Traditional lithography used 193 nm light. To move beyond the 10nm node, the industry adopted Extreme Ultraviolet (EUV) light.
Step 2: Standardization. The industry standardized on a specific emission peak generated by laser-produced tin plasma.
Step 3: The specific value. This wavelength is approximately 13.5 nm. It is so short that it is absorbed by air and glass, requiring the use of vacuum chambers and mirrors.
Conclusion: The standard wavelength for EUV lithography is 13.5 nm.

> Quick Tip
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> EUV Lithography = 13.5 nm. This extremely short wavelength is the key to making 7nm, 5nm, and 3nm chips.

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6. Which device is a three-dimensional gate structure designed to reduce short-channel effects in nanoscale MOSFETs?

(A) Bipolar Junction Transistor (BJT)
(B) FinFET
(C) Diode
(D) Capacitor

Correct Answer: (B) FinFET

Solution:

Understanding the Question: We are looking for a specific transistor design that uses a 3D gate to solve leakage problems in very small microchips.

Key Formulas and approach: As transistors shrink, the gate in a flat (planar) MOSFET can no longer turn the current off effectively (Short-Channel Effects). A 3D gate provides better electrical control.

Detailed Solution:
Step 1: Identifying the problem. In nanoscale chips, "short-channel effects" cause transistors to leak power even when off.
Step 2: The 3D Solution. The FinFET (Fin Field-Effect Transistor) uses a vertical "fin" of silicon as the channel.
Step 3: Gate Control. The gate wraps around this fin on three sides. This increased contact area allows the gate to "squeeze" the channel more effectively, stopping the leakage.
Conclusion: The FinFET is the 3D gate structure used to mitigate short-channel effects.

> Quick Tip
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> FinFET = Gate wraps around a 3D "Fin." This provides superior control compared to a flat (planar) gate.

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7. What happens to the optical absorption spectrum of a nanoparticle as its size is reduced?
(A) It shifts toward longer wavelengths (red shift)
(B) It shifts toward shorter wavelengths (blue shift)
(C) It remains unchanged
(D) It disappears completely

Correct Answer: (B) It shifts toward shorter wavelengths (blue shift)

Solution:

Understanding the Question: We need to determine how the light-absorption properties of a material change as its particle size enters the nanoscale.

Key Formulas and approach: Use the energy-wavelength relationship:

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

According to quantum confinement, smaller particles have a larger band gap (E_g).

Detailed Solution:
Step 1: Size and Energy Gap. As a nanoparticle gets smaller, the electrons are more confined, which increases the energy required to excite them (the band gap increases).
Step 2: Energy to Wavelength. Higher energy (E) corresponds to a smaller wavelength (λ).
Step 3: Defining the shift. A shift toward shorter wavelengths is known in physics as a "blue shift" (since blue is at the short-wavelength end of the visible spectrum).
Conclusion: Size reduction leads to a blue shift in the absorption spectrum.

> Quick Tip
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> Smaller Size → Higher Energy → Shorter Wavelength → Blue Shift.

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8. In a BJT, what is the primary consequence of the Early effect on the effective base width?
(A) The base width increases
(B) The base width decreases
(C) The base width remains constant
(D) The base width becomes zero

Correct Answer: (B) The base width decreases

Solution:

Understanding the Question: The question asks how the "Early Effect" (base-width modulation) physically changes the width of the base in a Bipolar Junction Transistor.

Key Formulas and approach: The "effective" base width is the physical width of the base minus the width of the depletion regions at the junctions.

Detailed Solution:
Step 1: Bias conditions. In a BJT, the Collector-Base (CB) junction is reverse-biased.
Step 2: Depletion region growth. As the reverse bias voltage on the collector increases, the depletion region at the CB junction expands.
Step 3: Modulating the base. Because this depletion region grows into the base area, the "neutral" part of the base where carriers can travel becomes thinner.
Conclusion: The Early effect results in a decrease of the effective base width.

> Quick Tip
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> Early Effect = Base-width modulation. Higher collector voltage "eats" into the base, making it narrower.

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9. Which type of counter requires 5 flip-flops to implement a MOD-31 operation?
(A) Synchronous counter
(B) Asynchronous (Ripple) counter
(C) Ring counter
(D) Johnson counter

Correct Answer: (B) Asynchronous (Ripple) counter

Solution:

Understanding the Question: We need to identify which counter uses 5 flip-flops to count up to 31 (a MOD-31 counter).

Key Formulas and approach: Different counters have different capacities per flip-flop (n):

- Binary/Ripple: States $= 2^n$
- Ring Counter: States $= n$
- Johnson Counter: States $= 2n$

Detailed Solution:
Step 1: Calculating for Binary. For a counter to reach 31, it must have at least 31 states. $2^5 = 32$. This matches the 5 flip-flop requirement.
Step 2: Checking other types. A Ring counter would need 31 flip-flops. A Johnson counter would need 16 flip-flops ($2 \times 16 = 32$).
Step 3: Identifying the correct type. The binary logic (where n flip-flops give 2^n states) is used by Asynchronous (Ripple) and Synchronous counters. Given the options, the Asynchronous counter is the standard answer.
Conclusion: The Asynchronous (Ripple) counter is correct.

> Quick Tip
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> MOD-N binary counter: Find n such that $2^n \geq N$. For $N = 31$, $n = 5$.

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10. For an ideal op-amp, what is the output voltage if the feedback resistance is equal to the input resistance in an inverting configuration?
(A) $V_o = V_{in}$
(B) $V_o = -V_{in}$
(C) $V_o = 0$
(D) $V_o = 2V_{in}$

Correct Answer: (B) $V_o = -V_{in}$

Solution:

Understanding the Question: We are asked for the output voltage of an inverting amplifier when the input and feedback resistors are the same.

Key Formulas and approach: The output voltage V_o for an inverting amplifier is:

$$V_o = -\left(\frac{R_f}{R_{in}}\right) V_{in}$$

Detailed Solution:
Step 1: Given values. We are told that the feedback resistance (R_f) equals the input resistance (R_{in}). So, $R_f = R_{in}$.
Step 2: Calculating the Gain.

$$\text{Gain} = -\frac{R_f}{R_{in}} = -\frac{R_{in}}{R_{in}} = -1$$

Step 3: Final Result. Since the gain is -1, the output voltage V_o is $(-1) \times V_{in}$.
Conclusion: $V_o = -V_{in}$.

Quick Tip

If $R_f = R_{in}$ in an inverting op-amp, the circuit is a Unity Gain Inverter. It just flips the sign.

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11. Which scientist is widely regarded as the Father of Nanotechnology?
(A) Albert Einstein
(B) Richard Feynman
(C) Niels Bohr
(D) James Clerk Maxwell

Correct Answer: (B) Richard Feynman

Solution:

Understanding the Question: The question asks us to identify the scientist who is historically recognized for laying the foundation of nanotechnology.

Key Formulas and approach: This is a factual historical question. Look for the scientist associated with the "plenty of room at the bottom" speech.

Detailed Solution:
Step 1: Historical Context. In 1959, the physicist Richard Feynman gave a famous talk at Caltech.
Step 2: The Vision. In his lecture "There's Plenty of Room at the Bottom," he described the possibility of manipulating individual atoms and molecules to build machines.
Step 3: Impact. This talk is considered the theoretical origin of the entire field of nanotechnology.
Conclusion: Richard Feynman is widely known as the Father of Nanotechnology.

Quick Tip

Feynman predicted that we would eventually be able to arrange atoms one by one.

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12. What is the word length of a standard 8085 microprocessor?
(A) 4-bit
(B) 8-bit
(C) 16-bit
(D) 32-bit

Correct Answer: (B) 8-bit

Solution:

Understanding the Question: We need to identify the data-processing capacity (word length) of the Intel 8085.

Key Formulas and approach: Word length refers to the size of the data bus and the capacity of the accumulator/ALU.

Detailed Solution:
Step 1: Analyzing the Data Bus. The 8085 has an 8-bit data bus.
Step 2: Analyzing the registers. The primary accumulator and registers in the 8085 are designed to store and process 8 bits of information at a time.
Step 3: Clarification. While the address bus is 16-bit, the data it actually processes (the word) is 8-bit.
Conclusion: The 8085 is an 8-bit microprocessor.

Quick Tip

Microprocessor "Bits" usually refer to the data word length. 8085 = 8-bit.

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13. In optical fibers, does the core or the cladding have a higher refractive index?
(A) Core
(B) Cladding
(C) Both are equal
(D) It varies randomly

Correct Answer: (A) Core

Solution:

Understanding the Question: The question asks to compare the refractive indices of the two layers of an optical fiber.

Key Formulas and approach: Optical fibers rely on Total Internal Reflection (TIR). For TIR to occur, light must travel from a medium with a higher refractive index (n_1) toward a medium with a lower refractive index (n_2).

Detailed Solution:
Step 1: The Goal. Light must stay trapped inside the center (the core) to transmit information.
Step 2: Applying Physics. To reflect light back into the core at the boundary, the outer layer (cladding) must be "thinner" optically.
Step 3: Relation. This means the refractive index of the core (n_{core}) must be greater than the refractive index of the cladding (n_{clad}).
Conclusion: The core has a higher refractive index.

> Quick Tip
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> For Total Internal Reflection: $n_{core} > n_{cladding}$.

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14. Which property refers to the inability to repeat recorded data when scanning from different directions?
(A) Reproducibility
(B) Hysteresis
(C) Directional anisotropy
(D) Noise interference

Correct Answer: (B) Hysteresis

Solution:

Understanding the Question: We are looking for the name of the error where a measurement's value depends on the direction or history of the scan.

Key Formulas and approach: This is a common phenomenon in sensors and actuators (like the piezo-scanners in AFMs) where the system lags behind the input signal.

Detailed Solution:
Step 1: Defining Hysteresis. Hysteresis is the dependence of a system's state on its past history.
Step 2: Scanning impact. If you scan a surface from left-to-right, and then right-to-left, the data points won't overlap exactly because the scanner doesn't return to the same spot for the same voltage.
Step 3: Identifying the term. This directional "lag" or "memory" is called Hysteresis.
Conclusion: The correct term is Hysteresis.

Quick Tip

Hysteresis = Directional lag. The "forward" path is different from the "reverse" path.

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15. What are the primary components of a lipid raft in the context of bio-nanoelectronics?

(A) DNA and RNA
(B) Proteins and carbohydrates
(C) Cholesterol and sphingolipids
(D) Enzymes and nucleotides

Correct Answer: (C) Cholesterol and sphingolipids

Solution:

Understanding the Question: The question asks for the specific molecular building blocks that make up a "lipid raft" in biological membranes.

Key Formulas and approach: Lipid rafts are specialized, rigid microdomains in the cell membrane used for signaling and sorting.

Detailed Solution:
Step 1: Biological Membrane. Most of the cell membrane is made of phospholipids, which are quite fluid.
Step 2: Raft Formation. Within this fluid membrane, certain lipids cluster together to form more "solid" islands or rafts.
Step 3: Specific Chemicals. These clusters are primarily composed of cholesterol (which stabilizes the structure) and sphingolipids (which pack tightly).
Conclusion: Cholesterol and sphingolipids are the main components of lipid rafts.

Quick Tip

Lipid Rafts = Stiff "islands" in the cell membrane. Key ingredients: Cholesterol + Sphingolipids.
