

CUET PG 2026 Nanoelectronics Question Paper with Solutions(Memory Based)

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| Time Allowed :1 Hour 30 Mins | Maximum Marks :300 | Total Questions :75 |
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General Instructions

Read the following instructions very carefully and strictly follow them:

- The exam lasts 90 minutes (1 hour 30 minutes).
- There are 75 Multiple Choice Questions (MCQs) to be answered.
- +4 marks for every correct answer. -1 mark (negative marking) for every incorrect answer. 0 marks for unanswered or un-attempted questions.
- For any discrepancy in questions, the English version is considered final (except for language-specific papers).
- Click one of the four options to choose an answer.
- You must click "Save & Next" to confirm your response. Only saved answers are considered for evaluation.
- Use "Mark for Review & Next" to flag a question for later. You can unselect or change your answer using the "Clear Response" button.
- All calculations must be done on the Rough Sheets provided at the centre. These must be returned to the invigilator after the exam.

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:

Concept:

Carbon exists in several structural forms known as **allotropes**. These allotropes differ in the arrangement of carbon atoms and their dimensional structure. In nanotechnology, carbon nanostructures are often classified based on their dimensionality:

- **0D nanostructures** – Fullerene (C_{60})
- **1D nanostructures** – Carbon nanotubes
- **2D nanostructures** – Graphene

- **3D structures** – Diamond and graphite

Step 1: Understanding one-dimensional nanostructures.

A **one-dimensional (1D) nanostructure** has one dimension that is significantly longer than the other two, giving it a wire-like or tubular shape. Electrons primarily move along one axis.

Step 2: Structure of carbon nanotubes.

Carbon nanotubes (CNTs) are cylindrical nanostructures formed by rolling a graphene sheet into a tube. They have diameters in the nanometer range but can be several micrometers long, making them ideal examples of 1D nanostructures.

Step 3: Eliminating other options.

- **Graphene** – A two-dimensional sheet of carbon atoms.
- **Fullerene** – A zero-dimensional spherical molecule.
- **Diamond** – A three-dimensional crystalline structure.

Conclusion:

Therefore, the carbon allotrope considered a **one-dimensional (1D) nanostructure** is the **carbon nanotube**.

Quick Tip

0D → Fullerene
1D → Carbon Nanotube
2D → Graphene
3D → Diamond

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:

Concept:

Carbon nanotubes (CNTs) are cylindrical nanostructures derived from graphene sheets. Their electronic properties depend strongly on their **chirality** and **diameter**. Depending on these structural parameters, carbon nanotubes can behave as either **metallic** or **semiconducting** materials.

The **band gap** is the energy difference between the valence band and the conduction band of a material, and it determines whether a material behaves as a conductor, semiconductor, or insulator.

Step 1: Relation between diameter and band gap.

For semiconducting carbon nanotubes, the band gap is inversely proportional to the nanotube diameter. This relationship can be approximately expressed as:

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

where:

- E_g = band gap energy
- d = diameter of the nanotube

Step 2: Effect of increasing diameter.

As the diameter of the nanotube increases, the curvature of the graphene sheet decreases. This causes the electronic structure to become closer to that of graphene, which has a very small or zero band gap.

Step 3: Resulting behavior.

Because of this inverse relationship, when the diameter increases, the band gap becomes smaller.

Conclusion:

Therefore, the band gap of a semiconducting chiral carbon nanotube **decreases as its diameter increases**.

Quick Tip

Band gap of CNT $\propto \frac{1}{\text{diameter}}$
Larger nanotube \rightarrow Smaller band gap

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:

Concept:

Nanomaterials are materials whose structural components have dimensions in the nanometer scale. At this scale, materials exhibit unique physical, chemical, electrical, and optical properties due to quantum effects and a high surface-to-volume ratio.

Step 1: Understanding the nanometer scale.

A nanometer (nm) is equal to:

$$1 \text{ nm} = 10^{-9} \text{ meters}$$

This extremely small scale is comparable to the size of atoms and molecules.

Step 2: Definition of nanomaterials.

According to international standards (such as ISO and scientific literature), nanomaterials typically have at least one dimension within the range of:

1 nm to 100 nm

Step 3: Examples of nanomaterials.

- Carbon nanotubes
- Quantum dots
- Nanowires
- Nanoparticles
- Graphene sheets

Conclusion:

Therefore, the characteristic length scale range for nanomaterials is **1–100 nanometers**.

Quick Tip

Nanomaterial size range → **1 nm to 100 nm**

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:

Concept:

Nanostructures are often classified based on how electrons are confined within them. Quantum confinement occurs when the dimensions of a material are comparable to the electron's de Broglie wavelength, restricting electron motion in certain directions.

Common classifications include:

- **Quantum Well** → Confinement in one dimension
- **Quantum Wire** → Confinement in two dimensions
- **Quantum Dot** → Confinement in three dimensions

Step 1: Understanding quantum dots.

A **quantum dot** is a nanoscale semiconductor particle where electrons are confined in all three spatial directions (x, y, and z).

Step 2: Effect of confinement.

Because electrons cannot move freely in any direction, quantum dots exhibit discrete energy levels similar to atoms. This is why they are often called “**artificial atoms.**”

Step 3: Resulting classification.

Since confinement occurs in all three dimensions, quantum dots are classified as **three-dimensional confinement structures.**

Conclusion:

Therefore, the degree of confinement for a quantum dot is **three-dimensional confinement.**

Quick Tip

Quantum Well → 1D confinement

Quantum Wire → 2D confinement

Quantum Dot → 3D confinement

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:

Concept:

Lithography is a key process in semiconductor manufacturing used to transfer patterns onto silicon wafers. As device sizes shrink to the nanoscale, shorter wavelengths of light are required to achieve higher resolution.

Step 1: Understanding EUV lithography.

Extreme Ultraviolet (EUV) lithography is an advanced lithographic technique used in modern semiconductor fabrication to produce extremely small integrated circuit features.

Step 2: Wavelength used in EUV systems.

EUV lithography uses radiation with a wavelength of approximately:

$$13.5 \text{ nm}$$

This extremely short wavelength enables patterning of very small transistor features used in modern processors.

Step 3: Importance in nanotechnology.

EUV lithography is widely used in advanced semiconductor manufacturing nodes such as 7 nm, 5 nm, and smaller technologies.

Conclusion:

Therefore, the standard wavelength used in EUV lithography is **13.5 nm.**

Quick Tip

EUV lithography wavelength → **13.5 nm**

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:

Concept:

As MOSFET devices shrink to nanoscale dimensions, they suffer from **short-channel effects**, where the gate loses control over the channel current. This leads to leakage currents and reduced device performance.

Step 1: Understanding FinFET structure.

A **FinFET (Fin Field-Effect Transistor)** is a three-dimensional transistor structure where the conducting channel is shaped like a vertical fin.

Step 2: Gate control improvement.

The gate wraps around the fin on multiple sides, providing better electrostatic control over the channel compared to traditional planar MOSFETs.

Step 3: Benefits of FinFET technology.

- Reduced short-channel effects
- Lower leakage current
- Higher switching speed
- Improved energy efficiency

Conclusion:

Therefore, the device that uses a three-dimensional gate structure to reduce short-channel effects in nanoscale MOSFETs is the **FinFET**.

Quick Tip

3D gate transistor used in modern chips → **FinFET**

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:

Concept:

Nanoparticles exhibit unique optical properties due to the **quantum confinement effect**. When the size of a particle approaches the nanoscale, the motion of electrons becomes confined, altering the electronic energy levels of the material.

Step 1: Understanding quantum confinement.

As the size of a nanoparticle decreases, the energy levels become more widely spaced because electrons are confined in a smaller region.

Step 2: Effect on energy transitions.

Larger spacing between energy levels means that a higher amount of energy is required for electronic transitions from the valence band to the conduction band.

Step 3: Effect on wavelength.

Since energy and wavelength are inversely related:

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

an increase in transition energy leads to a decrease in wavelength. This results in a **blue shift** in the absorption spectrum.

Conclusion:

Therefore, when the size of a nanoparticle decreases, its optical absorption spectrum shifts toward **shorter wavelengths (blue shift)**.

Quick Tip

Smaller nanoparticle → Larger band gap → Blue shift in absorption spectrum

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:

Concept:

The **Early effect** (also known as **base-width modulation**) occurs in a Bipolar Junction Transistor (BJT) when the collector-base junction voltage increases.

Step 1: Reverse bias of collector-base junction.

In normal transistor operation, the collector-base junction is reverse biased. Increasing this reverse bias causes the depletion region at the collector-base junction to widen.

Step 2: Effect on the base region.

As the depletion region expands into the base region, the **effective width of the base decreases**.

Step 3: Impact on transistor current.

A thinner base region allows more charge carriers to pass from emitter to collector, increasing the collector current slightly even if the base current remains constant.

Conclusion:

Therefore, the primary consequence of the Early effect is that the **effective base width decreases**.

Quick Tip

Early Effect → Base-width modulation → Effective base width decreases

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:

Concept:

A **MOD-N counter** is a digital counter that cycles through N distinct states before repeating the sequence. The number of flip-flops required depends on the number of states that must be represented.

Step 1: Determining the number of flip-flops.

The number of flip-flops required is determined by the smallest integer n satisfying:

$$2^n \geq N$$

where N is the modulus of the counter.

Step 2: Applying the formula for MOD-31.

For a MOD-31 counter:

$$2^5 = 32$$

Thus, **5 flip-flops** are required to represent at least 31 states.

Step 3: Type of counter implementation.

A commonly used implementation for such counters is the **asynchronous (ripple) counter**, where flip-flops toggle sequentially based on the output of the previous stage.

Conclusion:

Therefore, a **MOD-31 counter** requires **5 flip-flops**, and it is typically implemented using an **asynchronous (ripple) counter**.

Quick Tip

Number of flip-flops needed = $2^n \geq N$
MOD-31 $\rightarrow 2^5 = 32 \rightarrow 5$ flip-flops required

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:

Concept:

In an **inverting amplifier** configuration of an operational amplifier (op-amp), the input signal is applied to the inverting terminal through an input resistance R_{in} , while a feedback resistor R_f connects the output to the inverting input.

The gain of an ideal inverting amplifier is given by:

$$A_v = -\frac{R_f}{R_{in}}$$

Step 1: Applying the gain formula.

If the feedback resistance equals the input resistance:

$$R_f = R_{in}$$

then the voltage gain becomes:

$$A_v = -\frac{R_{in}}{R_{in}} = -1$$

Step 2: Determining output voltage.

Since the gain is -1 , the output voltage is the negative of the input voltage:

$$V_o = -V_{in}$$

Conclusion:

Therefore, when $R_f = R_{in}$, the output voltage of an ideal inverting op-amp is $V_o = -V_{in}$.

Quick Tip

Inverting amplifier gain: $A_v = -\frac{R_f}{R_{in}}$
If $R_f = R_{in} \rightarrow \text{Gain} = -1$

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:

Concept:

Nanotechnology is the science and engineering of manipulating matter at the atomic and molecular scale, typically within the range of 1–100 nanometers.

Step 1: Historical origin of nanotechnology.

The concept of nanotechnology was first introduced by physicist **Richard Feynman** in his famous 1959 lecture titled:

"There's Plenty of Room at the Bottom"

Step 2: Ideas proposed in the lecture.

In this lecture, Feynman discussed the possibility of:

- Manipulating individual atoms and molecules
- Miniaturizing machines and electronic components
- Building devices at extremely small scales

Step 3: Impact of his work.

Although practical nanotechnology developed decades later, Feynman's visionary ideas laid the theoretical foundation for the field.

Conclusion:

Therefore, **Richard Feynman** is widely regarded as the **Father of Nanotechnology**.

Quick Tip

Father of Nanotechnology \rightarrow **Richard Feynman**

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:

Concept:

The **word length** of a microprocessor refers to the number of bits it can process or handle simultaneously in a single operation.

Step 1: Understanding the 8085 microprocessor.

The **Intel 8085** is an early microprocessor widely used in microprocessor-based systems and educational applications.

Step 2: Data handling capability.

The 8085 microprocessor can process **8 bits of data at a time**. Therefore, its word length is 8 bits.

Step 3: Additional characteristics.

- 16-bit address bus
- 8-bit data bus
- Maximum addressing capability of 64 KB memory

Conclusion:

Thus, the word length of a standard **8085 microprocessor is 8-bit**.

Quick Tip

8085 Microprocessor → 8-bit processor with 16-bit address bus

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:

Concept:

An **optical fiber** is a flexible transparent fiber used to transmit light signals over long distances using the principle of **total internal reflection**.

Step 1: Structure of optical fiber.

An optical fiber consists of three main parts:

- Core

- Cladding
- Protective coating

Step 2: Refractive index relationship.

For total internal reflection to occur, the refractive index of the core must be slightly higher than that of the cladding.

Step 3: Propagation of light.

Because of this difference in refractive index, light entering the core reflects internally at the core–cladding boundary and travels through the fiber with minimal loss.

Conclusion:

Therefore, in optical fibers the **core has a higher refractive index than the cladding.**

Quick Tip

Optical fiber principle → Total internal reflection
 Core refractive index > Cladding refractive index

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:

Concept:

In nanoscale measurement techniques such as **Scanning Probe Microscopy (SPM)** or **Atomic Force Microscopy (AFM)**, certain physical effects can cause the measured signal to depend on the direction in which the probe scans the surface.

Step 1: Understanding hysteresis.

Hysteresis refers to the phenomenon where the response of a system depends on its previous history. In scanning systems, this means the output signal may vary depending on whether the probe scans forward or backward.

Step 2: Effect on recorded data.

Because of hysteresis in piezoelectric scanners or other system components, the recorded data may not be identical when scanning the same region from opposite directions.

Step 3: Impact in nanoscale measurements.

This leads to the **inability to reproduce identical data when scanning from different directions**, which is a characteristic symptom of hysteresis effects in measurement systems.

Conclusion:

Therefore, the property describing the inability to repeat recorded data when scanning from different directions is **hysteresis**.

Quick Tip

Measurement difference during forward and reverse scans → **Hysteresis**

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:

Concept:

Lipid rafts are specialized microdomains found within the cell membrane. These regions are enriched with specific lipids and proteins and play important roles in cellular signaling, membrane organization, and molecular transport. In bio-nanoelectronics, lipid rafts are studied for their potential use in biomolecular sensing and nanoscale device interfaces.

Step 1: Structure of the cell membrane.

The cell membrane is composed mainly of a **phospholipid bilayer**. Within this bilayer, certain lipids cluster together to form lipid raft domains.

Step 2: Key molecular components.

Lipid rafts are primarily composed of:

- **Cholesterol**
- **Sphingolipids**

These molecules create tightly packed, ordered regions within the membrane.

Step 3: Role in bio-nanoelectronics.

Because lipid rafts concentrate signaling proteins and receptors, they are important in:

- Biosensor design
- Membrane-based nanodevices
- Molecular signal transduction studies

Conclusion:

Thus, the primary components of lipid rafts are **cholesterol and sphingolipids**.

Quick Tip

Lipid raft composition → **Cholesterol + Sphingolipids**