Q1. Consider the following statements regarding quantum dots:

1. A quantum dot is a nanoparticle made of any semiconductor material.
2. The lab tests have shown that these quantum dots are more than 90% effective at wiping out antibiotic-resistant germs.
3. In the dark, the QDs remain inactive. When bombarded by visible light, they become energetically excited.

How many of the statements given above is/are correct?

(a) Only one
(b) Only two
(c) All three
(d) None

Ans: (c)

Explanation:

- **What are Quantum dots?**

- A quantum dot is a nanoparticle made of any semiconductor material such as silicon, cadmium selenide, cadmium sulfide, or indium arsenide. They are essentially small crystals of nanometer-size dimensions – they're about 20,000 times smaller than the width of a human hair. They are each one million times smaller than a millimeter. They have distinctive electrical conduction properties that are determined by the incredibly small size and structure.
- When these QDs are hit with a specific frequency of radiation, their changeable structure, tailored by scientists, means that they can be finely tuned to emit a specific frequency of radiation; changing the wavelength of the light source can achieve the same effect.
- In the dark, the QDs remain inactive. When bombarded by visible light, they become energetically "excited."

- **Why we need them?**

- Super-bacteria resistant to the latest antibiotics, the last line of medical defence against various infections, cancer and HIV, is on the rise. These superbugs use evolutionary abilities to overwhelm medical advances. And to contain these bugs has been a challenging task for the scientists across the world.

- **What led to their rise?**

- The rampant, indiscriminate administration of common antibiotics has allowed these bacteria the ability to shuffle their genes and defeat these drugs. Such bacteria include Salmonella, Staphylococcus and E. coli.

Q2. What are quantum dots?

(a) Tiny robots used in nanomedicine to deliver drugs to specific cells.
(b) Nanoscale semiconducting particles with unique optical properties.
(c) Subatomic particles used in quantum computing for data storage.
(d) A type of subatomic particle found in the nucleus of atoms.

Ans: (b)

Explanation:

- B) Quantum dots are nanoscale semiconductor particles that have unique optical and electronic properties due to their small size. They are often used in various applications, including display technology, medical imaging, and solar cells, because they can emit light of different colors depending on their size. This property makes them valuable in technologies such as quantum dot displays and quantum dot-based sensors.
- A) This statement is incorrect. Quantum dots are not tiny robots; they are semiconductor nanoparticles.
- C) This statement is incorrect. Quantum dots are not subatomic particles used in quantum computing; they are a different class of nanomaterial.
- D) This statement is incorrect. Subatomic particles found in the nucleus of atoms include protons and neutrons, not quantum dots.

Q3. Consider the following statements:

1. Statement 1: Quantum dots can be used to create displays that are more energy-efficient and have a wider color gamut than traditional displays.
2. Statement 2: Quantum dots can be used to develop solar cells that are more efficient and less expensive than traditional solar cells.
3. Statement 3: Quantum dots can be used to develop new types of medical imaging probes that can be used to diagnose and treat diseases.

How many of the statements given above is/are correct?

(a) Only one

(b) Only two

(c) All three

(d) None

Ans: (c)

Explanation:

- **Application Description Examples:**

- Display Technology - Enhance display quality in QLED screens - Samsung QLED TVs
- Lighting - Adjust the colour temperature in LED lamps - Nanoco LED lighting solutions
- Biomedical Imaging - Map cells and organs for research and diagnostics - Quantum dots for cancer imaging
- Drug Delivery - Targeted drug delivery for therapy - Quantum dots for drug delivery
- Photovoltaics - Improve solar cell efficiency - Quantum dot solar cells
- Sensing and Detection - Detect and measure specific substances - Quantum dot sensors
- Quantum Computing - Quantum bits (qubits) in quantum computing - Quantum dot-based qubits
- Security Marking - Anti-counterfeit markers on currency and documents - Security applications

Q4. Consider the following statements regarding Quantum computing:

1. Quantum computer works on the principle of Superposition, which makes it possible for the qubit to exist in both 0 and 1 state simultaneously.
2. As more qubits are added, the processing capability of the quantum computer increases exponentially.
3. Building a quantum computer requires very cold temperatures and extreme isolation.

How many of the statements given above is/are correct?

(a) Only one

(b) Only two

(c) All three

(d) None

Ans: (c)

Explanation:

- Conventional computers store and process information in bits. A bit is the smallest unit of data that computers can handle. It can take just two values — 0 or 1 — but only one of these at a time. A zero would result in a certain set of instructions to be carried out, while a one would lead to a different set of instructions. All data in computers, including text, pictures and videos, are broken down into a sequence of zeros and ones for purposes of storage and processing, and can be reconstructed from these.
- A two-bit system in a conventional computer can have four states — (0,0), (0,1), (1,0) and (1,1) — but again only one at a time. To go through each of these four states, the computer has to take four steps. A more powerful computer can speed up the process, but it would still have to go through the four steps.
- This is where the quantum computer starts to do things differently. Superposition makes it possible for the quantum bit, or a qubit as it is called, to exist in both 0 and 1 state simultaneously. Counter-intuitive as it may appear, it can be 60 per cent 0 and 40 per cent 1 at the same time, or any other combination. Similarly, the two-qubit system can be in all four states at the same time — some part (0,0), some part (0,1), some part (1,0) and remaining (1,1). What it

means is that a quantum computer can go through these four states in one step, unlike the conventional computer that requires four steps.

- As more qubits are added, the processing capability of the quantum computer increases exponentially. With just a few qubits, say 50, quantum computers can outpace traditional computers that perform a couple of billion operations per second.
- Apart from the challenges in building a quantum computer — requirements of very cold temperatures and extreme isolation — there is a significant risk of errors. The parallel processing happening in superposition states all lead to different results, only one of which is correct or desirable. In other situations, when the superposition breaks down, the final outcome is randomly selected from the range of possibilities.

Q5. Consider the following statements regarding quantum mechanics:

1. Quantum computers use quantum mechanics to solve problems too complex for regular computers.
2. In the entangled quantum states, the two separate particles behave like a single unit.
3. Quantum teleportation is a phenomenon which makes it possible to move a quantum state from one particle to one at a distance.

How many of the statements given above is/are correct?

(a) Only one

(b) Only two

(c) All three

(d) None

Ans: (c)

Explanation:

- The Nobel Prize for Physics 2022 was shared by three scientists for their work on quantum mechanics.

- The three conducted a series of experiments on something called entangled quantum states, where two separate particles behave like a single unit. Their pathbreaking results will have implications in the fields of quantum computers, quantum networks and secure quantum encrypted communication. Put simply, quantum computers use quantum mechanics to solve problems too complex for regular computers.
- A phenomenon called quantum teleportation, which makes it possible to move a quantum state from one particle to one at a distance."