

Transmission Electron Microscope (TEM): Questions and Answers

I. Short Answer Questions (10 Questions)

1. Who developed the Transmission Electron Microscope? (Remember)

Answer: Ernst Ruska and Max Knoll developed the first Transmission Electron Microscope in 1931.

2. What is the main principle behind the Transmission Electron Microscope? (Understand)

Answer: TEM works on the interaction of high-energy electrons with thin specimens to form an image based on electron transmission and scattering.

3. Why is a vacuum required in a TEM? (Understand)

Answer: A vacuum prevents electrons from colliding with air molecules, ensuring a clear and focused beam.

4. What is the typical accelerating voltage used in a TEM? (Remember)

Answer: Typically, TEMs operate at voltages between 60 kV and 300 kV.

5. Name two commonly used fixatives in TEM specimen preparation. (Remember)

Answer: Glutaraldehyde and osmium tetroxide are commonly used fixatives.

6. What is the typical thickness of a specimen section for TEM analysis? (Remember)

Answer: Specimens are usually sectioned to a thickness of 50–100 nanometers.

7. How is contrast generated in a TEM image? (Understand)

Answer: Contrast arises from differential scattering of electrons by dense and less dense areas of the specimen.

8. What type of lenses are used in a TEM instead of glass lenses? (Remember)

Answer: Electromagnetic lenses are used to focus and control the electron beam.

9. Mention one major advantage and one limitation of the TEM. (Understand)

Answer: Advantage: Extremely high resolution. Limitation: Complex sample preparation and vacuum requirement.

10. Define the term 'resolution' in the context of TEM. (Remember)

Answer: Resolution is the ability of the microscope to distinguish two points as separate at the smallest possible distance.

II. Short Essay Questions (10 Questions)

1. Explain how the de Broglie hypothesis is relevant to the principle of the Transmission Electron Microscope. (Understand)

Answer: The de Broglie hypothesis states that particles such as electrons have wave-like properties. The shorter wavelength of electrons allows the TEM to achieve much higher resolution than light microscopes.

2. Describe the major components of a TEM and state the function of each. (Understand)

Answer: Major components include the electron gun (produces electrons), condenser lens (focuses the beam), specimen stage (holds the sample), objective lens (forms the initial image), and projector lens (magnifies the image).

3. Discuss the importance of thin sectioning in TEM sample preparation. (Apply)

Answer: Thin sections, typically 50–100 nm, are essential for electron penetration; thicker samples scatter too many electrons, reducing image clarity.

4. Outline the sequential steps in the preparation of a biological specimen for TEM observation. (Remember/Understand)

Answer: Steps include fixation, dehydration, embedding, ultrathin sectioning, and staining with heavy metals.

5. Compare the working principles of the Transmission Electron Microscope (TEM) and the Scanning Electron Microscope (SEM). (Analyze)

Answer: TEM transmits electrons through a thin specimen to view internal structure, while SEM scans the surface to produce 3D-like images of external morphology.

6. Explain how heavy metal staining enhances image contrast in TEM. (Apply)

Answer: Heavy metals such as lead and uranium scatter electrons strongly, enhancing contrast by making dense regions appear darker.

7. Describe how TEM can be applied to study viruses and their structures. (Apply)

Answer: TEM reveals viral morphology, symmetry, and structural details that help in virus classification and studying infection mechanisms.

8. Explain the role of electromagnetic lenses in focusing the electron beam. (Understand)

Answer: Electromagnetic lenses bend and focus the path of electrons using magnetic fields, similar to how glass lenses bend light rays.

9. Analyze the advantages and disadvantages of using TEM for biological research. (Analyze)

Answer: Advantages include ultra-high resolution and visualization of subcellular structures. Disadvantages include complex preparation and inability to observe living cells.

10. Discuss how cryo-electron microscopy has improved upon the limitations of conventional TEM. (Evaluate)

Answer: Cryo-TEM allows specimens to be imaged in near-native hydrated states without chemical fixation, minimizing artifacts and preserving structural integrity.

III. Essay Questions (3 Questions)

1. Describe in detail the working principle of the Transmission Electron Microscope. (Understand/Analyze)

Answer: The Transmission Electron Microscope operates by transmitting a beam of electrons through a thin specimen. Electrons are emitted by an electron gun and accelerated under high voltage. Electromagnetic lenses focus the beam, and the transmitted electrons form an image based on density differences. The resulting image is projected onto a fluorescent screen or camera, providing a detailed view of the internal structure of the specimen.

2. Evaluate the role of the Transmission Electron Microscope in modern biological sciences. (Evaluate)

Answer: TEM plays a vital role in cell biology, microbiology, virology, and pathology. It provides insights into organelle structures, bacterial ultrastructure, and viral morphology. Despite its limitations—such as high cost, need for vacuum, and complex preparation—TEM remains indispensable for understanding cellular organization at nanometer resolution.

3. Propose modern improvements or techniques that can minimize artifacts in TEM specimen preparation. (Create)

Answer: Artifacts can be reduced through rapid freezing and cryo-fixation, which preserve cellular structures in a near-native state. Cryo-TEM avoids dehydration and chemical fixation, while advanced digital detectors enhance image clarity. Automation and low-dose imaging further protect delicate biological samples from electron damage.