



Transmission Electron Microscope (TEM) – 16 Marks

◆ 1. Introduction

- A **Transmission Electron Microscope (TEM)** is a powerful microscope that uses a **beam of electrons** to see the **internal structure** of very small objects.
 - It provides images with **very high resolution**, even showing **atoms** in some materials.
 - Developed in 1931 by **Ernst Ruska**.
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◆ 2. Working Principle

- A **high-energy electron beam** is transmitted **through an ultra-thin specimen**.
 - As electrons pass through the sample, some are **scattered**, while others are transmitted.
 - The transmitted electrons are used to form an image on a **fluorescent screen** or **camera**.
 - The contrast in the image comes from how different parts of the sample **absorb or scatter electrons**.
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◆ 3. Construction / Parts

- **Electron Gun**: Generates high-energy electrons.
 - **Condenser Lenses**: Focus the electron beam onto the specimen.
 - **Specimen Stage**: Holds the ultra-thin sample.
 - **Objective Lens**: Creates the first magnified image.
 - **Projector Lenses**: Further magnify the image.
 - **Fluorescent Screen / Camera**: Displays or captures the image.
 - **Vacuum Chamber**: Maintains vacuum to avoid interference from air particles.
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◆ 4. Steps in TEM Operation

1. Sample is prepared as an **ultra-thin section (~100 nm thick)**.
 2. Electron beam passes through the sample.
 3. Denser areas scatter more electrons and appear **darker**.
 4. Transmitted electrons form a **detailed 2D image** on the screen.
 5. Image is magnified and can be recorded digitally.
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5. Properties / Characteristics

- **Extremely high resolution** (~0.1 nm).
 - Can view **internal structures** of cells and materials.
 - Requires **very thin and dry samples**.
 - Works only in a **vacuum** environment.
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6. Applications

- **Biology:** Study of cell organelles (e.g., mitochondria, viruses).
 - **Material science:** Grain boundaries, dislocations, and defects in crystals.
 - **Nanotechnology:** Viewing nanoparticles, nanotubes.
 - **Medical research:** Virus and protein structure analysis.
 - **Semiconductor industry:** Internal inspection of microchips.
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7. Advantages

- **Highest magnification and resolution** of all microscopes.
 - Allows study of **internal ultra-structure**.
 - Clear, detailed **2D images** at the atomic level.
 - Helpful in **scientific and industrial research**.
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8. Disadvantages

- **Very expensive** and large.
 - Needs **high vacuum** and **specialized sample preparation**.
 - Sample must be **ultra-thin**, non-living, and dry.
 - Requires **skilled personnel** to operate.
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9. Diagram Description

- Show:
 - Electron gun at the top
 - Condenser lens
 - Specimen holder
 - Objective lens
 - Projector lens
 - Screen at the bottom

Caption: *Working of TEM – Electron beam passes through thin sample to form magnified internal image.*

11. Summary

- **TEM** is a powerful electron microscope that shows the **internal structure** of thin samples.
 - Uses **transmitted electrons** for imaging.
 - Common in **biology, medicine, and materials science**.
 - Offers **high detail**, but needs **advanced setup and sample prep**.
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