Department of materials science and engineering, National United University Jun. 8, 2026 9:00 – 11:00

(A) Select the correct answer from the list (60%)

1. Which of the following lens is to focus the beam onto the sample surface in SEM? (a) condenser lens (b) eyepieces (c) objective lens (d) projective lens (e) none of the above
2. Which of the following are low energy electrons formed by inelastic scattering and have energy of less than 50 eV? (a) Auger electrons (b) secondary electrons (c) backscattered electrons (d) photoelectrons (e) pair-production electrons
3. About the edge effect, which of the following is not true? (a) It makes the edges and peaks brighter (b) Electrons preferentially flow to and are emitted from edges and peaks. (c) Increasing the beam kV can reduce edge effect. (d) It is also enhanced by back scattered electrons. (e) Tips are typically brighter than edges.
4. Which of the following description is wrong? (a) vent -> introduce air into the chamber (b) evacuation -> remove the air from chamber by pumping (c) TV rate -> fast scan (d) stigmators (X and Y) -> remove streaky or blurry image (e) spot size -> adjust magnification
5. Which of the following cannot reduce the charging effect? (a) Lowering kV (b) Increasing probe current (c) Coating conductive layer (e.g. Au, Pt, C) on sample surface (d) Low vacuum (e) A fast scan rate
6. Secondary electrons produced by backscattered electrons with the sample are termed (a) SE1 electrons (b) SE2 electrons (c) SE3 electrons (d) Auger electrons (e) backscattered electrons
7. The first lens distance is denoted by L_1 and its focal length is denoted by f_1. What is the definition of demagnification? (a) $\frac{f_1}{L_1}$ (b) $\frac{L_1}{f_1}$ (c) $f_1 \times L_1$ (d) $f_1 + L_1$ (e) $L_1 - f_1$
8. The higher the lens strength of the objective, (a) the shorter the focus length (b) the smaller the demagnification (c) the larger the spot size (d) the larger the working distance (e) the larger the depth of focus
9. Which of the following description is not true? (a) Increase the demagnification will decrease the spot size (b) Increase the demagnification will decrease the semi angle (c) Increase the demagnification will improve the SEM spatial resolution (d) Increase the demagnification will decrease depth of focus (e) Better spatial resolution inevitably reduces the available probe current.
10. Regarding solid angle, which of the following is not true? (a) The solid angle Ω is the 2-D analog of the conventional 1-D angle θ. (b) The unit is steradian (c) The steradian is a dimensionless unit. (d) The total solid angle in one sphere is 2π (e) The solid angle inside a cone of half-angle α is $\pi\alpha^2$ for $\alpha \ll 1$.
11. As you know about spherical and chromatic aberration, which of the following is not true? (a) Spherical aberration can be reduced by using small apertures. (b) Chromatic aberration can be reduced by using small apertures. (c) Chromatic aberration increases with increasing energy spread at the electron gun. (d) Chromatic aberration will be worse for high primary beam voltages. (e) Variations in the lens current cause chromatic aberration.
12. Diffraction limit in SEM is most affected by (a) energy spread (b) semi-angle (c) round lens systems (d) electron wavelength (e) beam current
13. Considering the signal to noise ratio, at low primary beam voltages (1 keV), the best semi-angle can be obtained by (a) spherical aberration = chromatic aberration (b) spherical aberration = diffraction limit (c) chromatic aberration = diffraction limit (d) spherical aberration = current limit (e) chromatic aberration = current limit
14. Which of the following is formed by interferences between electrons traveling along the axis of the lens and electrons scattered at the edge of the lens? (a) astigmatism (b) spherical aberration (c) chromatic aberration (d) diffraction limit (e) coma
15. Which of the following will improve the SE image resolution? (a) decreasing the working distance (b) increasing the probe current (c) decreasing the accelerating voltage (d) increasing the probe diameter (e) increasing the aperture size
16. Which of the following best describes the physical structure of a scintillator? (a) A silicon wafer coated with gold (b) A metal disk coated with carbon (c) A ceramic plate coated with tungsten (d) A thin plastic or glass disk coated with a short-persistence phosphor (e) A copper mesh coated with graphite
17. What is the main reason a photomultiplier tube is extremely sensitive to weak light signals? (a) It uses a high accelerating voltage to generate X-rays. (b) The scintillator emits visible light directly to the display screen. (c) Successive dynodes amplify the signal through electron multiplication. (d) The anode generates additional photons. (e) The detector operates at cryogenic temperatures.
18. A specimen contains a flat region of tungsten adjacent to aluminum. In COMPO mode, the tungsten region will most likely appear (a) darker because it absorbs more electrons (b) brighter because it produces more backscattered electrons (c) identical in brightness to aluminum (d) bright only if the specimen is tilted (e) dark only at low accelerating voltage
19. Which sequence correctly describes the formation of an EBSD pattern? (a) Incident electrons → Secondary electron emission → X-ray generation → Kikuchi bands on a phosphor screen (b) Incident electrons → Bragg diffraction by crystal planes → Kikuchi bands on a phosphor screen (c) X-ray diffraction → electron-hole pair generation → Kikuchi bands on a phosphor screen (d) Incident electrons → Backscattered electrons → photomultiplier tube → Kikuchi pattern (e) Incident electrons → secondary electrons → phosphor fluorescence.
20. Which crystallographic plane produces the narrower Kikuchi band? (a) Plane with larger d-spacing (b) Plane with smaller d-spacing (c) Both have identical width (d) Depends only on accelerating voltage (e) Depends only on crystal orientation

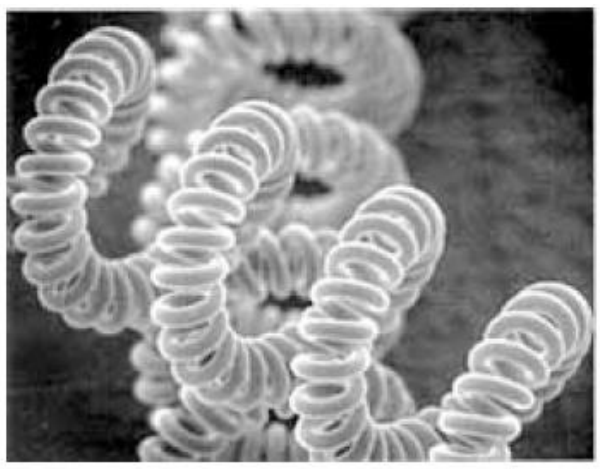
(B) Answer the following questions (50%)

21. Explain source demagnification and final semi-angle at the specimen associated with focal length of lenses. (10%)

22. The total beam diameter is determined by quadrature equation shown below. Explain each term in the quadrature equation. What are the limiting factors of the image resolution for tungsten and field-emission source, respectively? (10%)

$$d_p^2 = C_0^2\alpha_p^{-2} + (0.6\lambda)^2\alpha_p^{-2} + \frac{1}{4}C_s^2\alpha_p^6 + \left(C_c\frac{\Delta E}{E}\right)^2\alpha_p^2$$

23. The SEM image shown below is a bit blurred in the background. What parameters will you try to change to get everything in the image clear? Why? (10%)



(a) OL aperature diameter: 600μm WD: 10mm

24. Where do backscattered electrons and secondary electrons come from? (6%) Explain why the resolution of the backscattered electrons is worse than that of secondary electrons? (2%) What additional information can backscattered electrons provide but secondary electrons cannot? (2%)

25. Describe the working principle of secondary electron (Everhart-Thornley) detectors. (10%)