

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

1. Which of the following description is not true? (a) Increase the demagnification will decrease the spot size (b) Increase the demagnification will increase the semi angle (c) Increase the demagnification will degrade the SEM spatial resolution (d) Increase the demagnification will decrease depth of focus (e) Better spatial resolution inevitably reduces the available probe current.
2. Which of the following description about thermionic gun is not true? (a) A current is passed through the cathode and heats it to high temperatures so that electrons are emitted from the cathode surface (b) The Wehnelt electrode is biased positively with respect to the cathode voltage (c) The Wehnelt electrode has the effect of focusing the emitted electrons, effectively reducing the source size (d) The emission current from the cathode is usually limited by a space charge effect, where the slower moving emitted electrons form a negatively charged cloud above the cathode tip. (e) The emission current naturally comes to its own equilibrium.
3. Which of the following description about field emission gun is not true? (a) Electrons leave the cathode tip via quantum tunneling (b) Electrons emitted from field emission guns form a real crossover (c) The suppressor electrode is negatively biased and has the effect of pushing the emitted electrons forward. (d) The radius of curvature of the cathode tip in field emission gun can be as low as $0.01\ \mu\text{m}$. (e) A high electric field strength at the cathode surface is created, typically around $10^9\ \text{V/m}$ or greater.
4. Which of the following is not the disadvantage of field emission gun over thermionic gun? (a) easily poisoned (b) require high vacuum (c) stable current (d) expensive (e) limited microanalysis
5. About brightness, which of the following is not true? (a) The brightness of a source of light quantifies the degree of directionality for light emitted by an object. (b) The brightness of a light source can be increased with passive optical components such as lenses, mirrors, or waveguides. (c) The brightness of the image is independent of the degree of focusing by the lens, indicating that the brightness is unchanged before and after focusing. (d) For a given SEM column, the brightness is a constant along the primary beam path. (e) The brightness of a gun approximately rises linearly with the accelerating voltage.
6. Chromatic aberration in SEM is most influenced by (a) accelerating voltage (b) semi-angle (c) round lens systems (d) energy spread (e) beam current
7. C_s and C_c are the spherical and chromatic aberration coefficients of the lens, respectively. α is the aperture-limited semi-angle. The disc of least confusion in spherical and chromatic aberration are d_s and d_c , respectively. Which of the following description is not true? (a) For round lens systems, C_s cannot be zero. (b) For round lens systems, C_c cannot be zero. (c) d_s is proportional to C_s . (d) d_c is proportional to C_c . (e) d_s is proportional to α .
8. Considering the signal to noise ratio, at low primary beam voltages (1 keV), which of the following dominates in broadening the spot size in FESEM? (a) current effect (b) spherical aberration (c) chromatic aberration (d) diffraction limit (e) none of the above
9. Which of the following occurs because paraxial rays passing through a lens are brought to a focus at a point which is further away from the lens than peripheral rays? (a) astigmatism (b) spherical aberration (c) chromatic aberration (d) diffraction limit (e) coma
10. Which of the following is used to deflect the beam in the X and Y axes so that it scans in a raster fashion over the surface of the sample? (a) scanning coil (b) astigmator (c) objective lens (d) condenser lens (e) aperture
11. Which magnification in SEM will make the deflection aberrations, e.g. coma, field curvature, distortion, astigmatism, etc, worse? (a) 200,000X (b) 100,000X (c) 50,000X (d) 10,000X (e) 27X
12. Which of the following can not increase the SE collection efficiency? (a) low energy SE (b) high energy SE (c) increasing working distance (d) tilt sample (e) none of the above
13. BSEs emitted at which polar angle come from a much smaller interaction volume located close to the specimen surface (within several nano-meters)? (a) 1° (b) 30° (c) 45° (d) 60° (e) 89°
14. Which of the following does not appear when increasing the accelerating voltage? (a) Lack of detailed structures of specimen surfaces (b) Remarkable edge effect (c) Higher possibility of charge-up (d) Higher possibility of specimen damage (e) lower resolution
15. Which of the following is not required in the SEM-EDS detector? (a) heating (b) cryostate (c) vacuum (d) electron trap (e) none of the above
16. Which of the following is wrong? (a) The lighter elements have high fluorescence yields (b) For lighter elements, Auger electron will be produced rather than an X-ray photon. (c) Low-energy X-rays are more likely to be absorbed than those with higher energies. (d) Elements with higher atomic numbers tend to be strong absorbers of lower energy X-rays. (e) The longer the path length, the more likely the X-ray will be absorbed.
17. Which of the following will increase the dead time? (a) Decrease the beam current (b) Increase the spot size (c) increase the time constant (d) decrease the processing time (e) None of the above
18. The dead layer is a layer at the silicon crystal surface of the EDS detector. Which of the following description is wrong? (a) Remain excess holes (b) Result in incomplete charge collection (c) Charge trapping may occur (d) The size of the detected charge pulse is

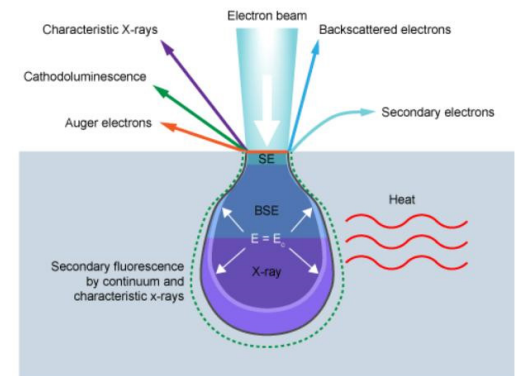
reduced (e) A tail appears on the high-energy side of the detected peak

19. For EDS quantitative analysis, which of the following is wrong? (a) Using high accelerating voltage (b) Using large beam current (c) the sample needs homogeneous (d) Apply conductive coating on insulating samples (e) For complex samples, Au and Pt are better choices for coating materials than graphite.

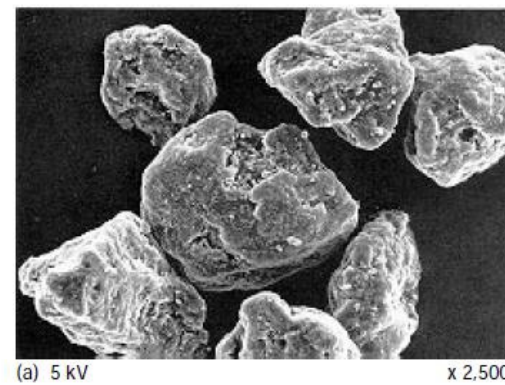
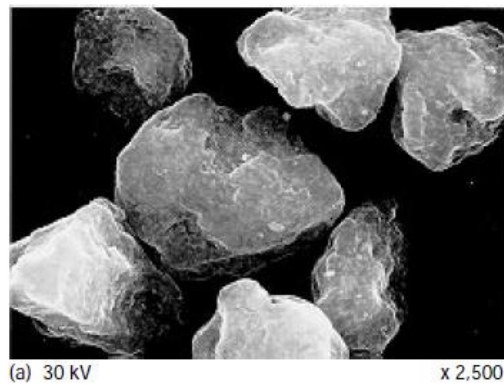
20. Which of the following has the highest characteristic X-ray energy for an element? (a) K_{α} (b) K_{β} (c) L_{α} (d) L_{β} (e) M_{α}

(B) Answer the following questions (50%)

21. Explain why the signal of secondary electrons comes from the near-surface of the sample, while the signal of characteristic X-ray escapes from deep sites within the interaction volume? (10%)



22. The two morphologies shown below are a bit different. Please explain the reasons. (10%)



23. How can you achieve high resolution of the image in a scanning electron microscope? How does working distance influence resolution and depth of field? (10%)

24. One of the limitations of quantitative EDS analysis is the light elements in the sample. Explain why light elements cannot be correctly quantified in EDS analysis. (10%)

25. What are the matrix correction in quantitative X-ray analysis? Explain each part of the matrix correction. (10%)