The SEM is widely used to analyze the surface morphology and chemical composition of the tested materials. Its working principle is mainly based on detecting signals from the interaction of the incident electrons with the sample's surface. The signals gathered in an SEM include the secondary electrons, backscattered electrons and characteristic x-rays etc. Quality of the images is greatly affected by a number of operation parameters. In this assignment, you are required to discuss the influence of these operation parameters based on the given SEM images/data.

1. **Influence of Working Distance (WD) (2 marks)**

Fig 1 (a) and (b) are SEM secondary electron (SE) images for a composite material with carbon fibres taken with different WD. Interpret the images and explain the influence of WD.

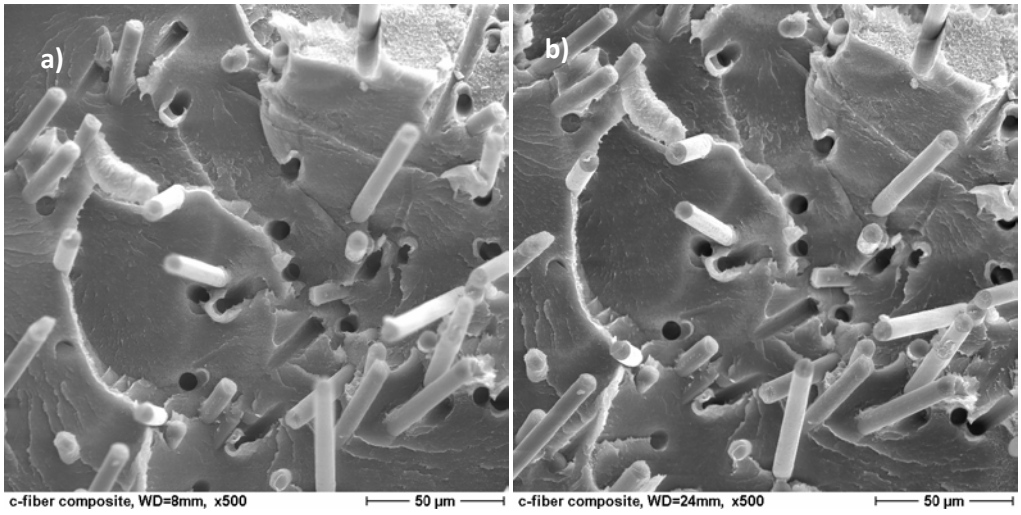


Figure 1 a) WD= 8mm. b) WD= 24mm.

2. **Influence of Acceleration Voltage (HV) (2 marks)**

A copper grid with a polymer thin film coating on top is used to study the influence of acceleration voltage (HV).Fig 2 (a) and (b) are SE images of the sample using different HV. Explain why different images are observed on the same sample and discuss the influence of HV.

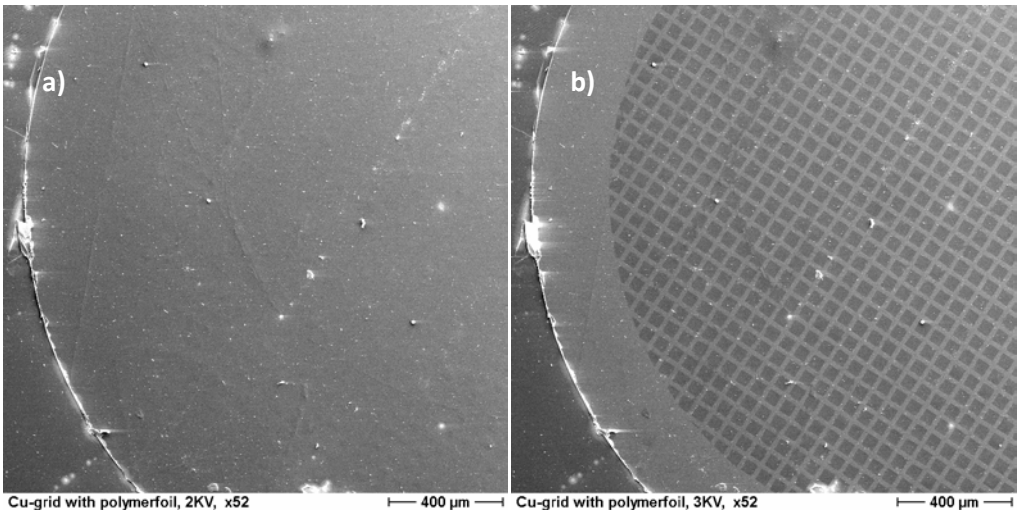


Figure2, a) HV= 2kV. b) HV= 3kV

3. Influence of Aperture and Scan Rate (2 marks)

Iron oxide powder is used to look at the influence of aperture and scanning speed. Fig 3 (a) and (b) are the SE images obtained using the aperture size of 140 µm to 70 µm with same scan rate. Whereas the image in Fig 3 (c) is taken using a slow scan rate with an aperture size of 70 µm. Based on the three images, discuss how the aperture and scan rate affect the quality of image.

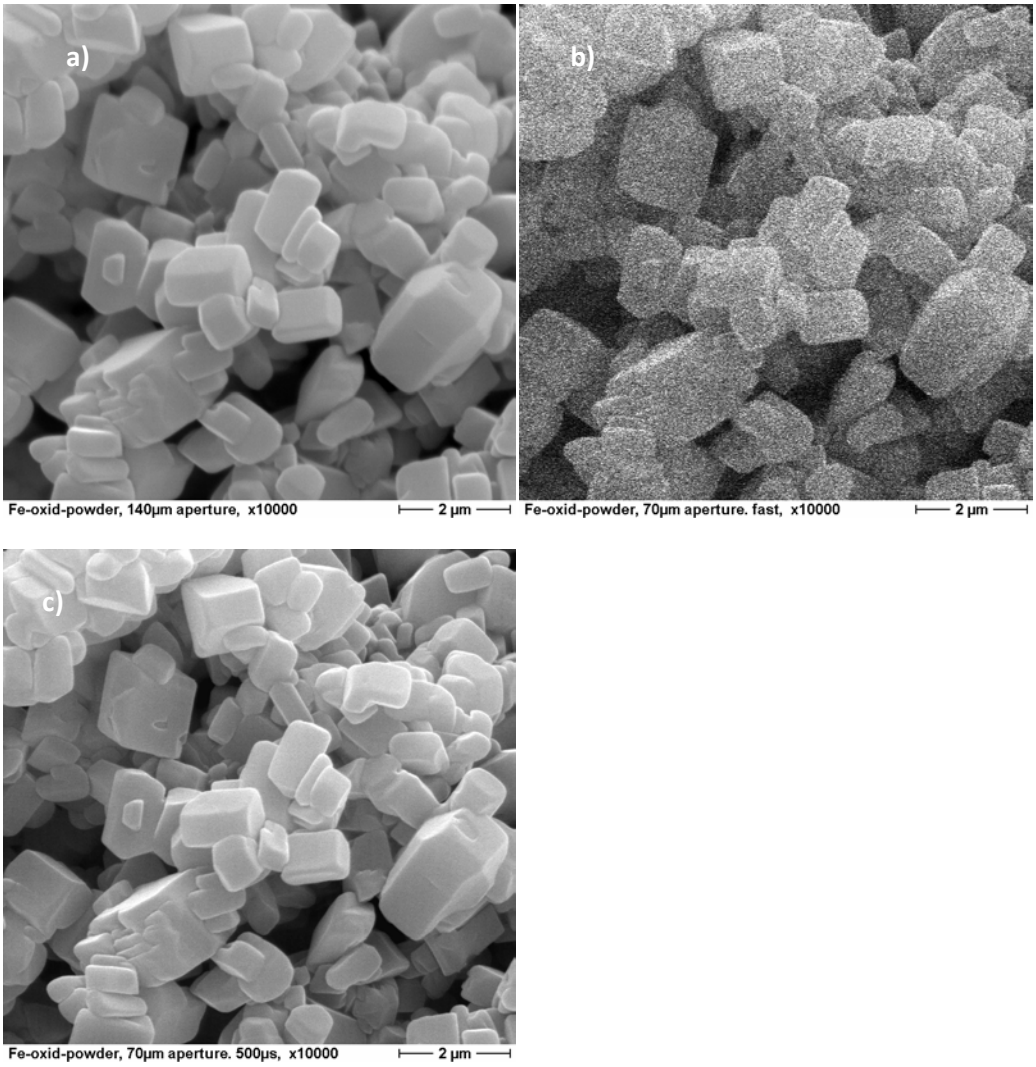


Figure 3, a) R=140µm. b) R=70µm with fast scan rate. c) R=70µm with slow scan rate.

4. Influence of received electron type (2 marks)

In SEM, both secondary electron (SE) and backscattered electron (BSE) will render images of surface morphology of the sample. One of the two images below is SE image and the other is BSE image. Differentiate them with explanations. The sample is iron oxide powder with impurities.

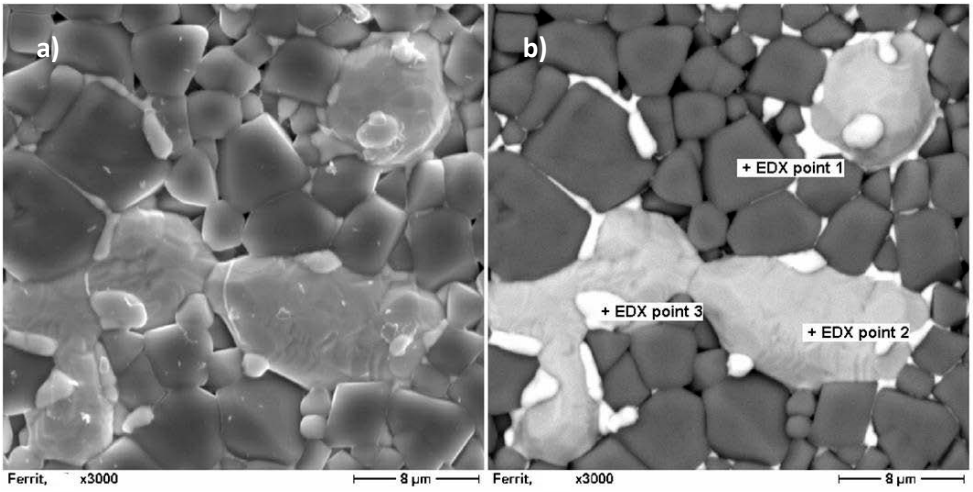


Figure 4, SE and BSE images of iron oxide powder with impurities.

5. Chemical analysis with energy dispersive X-ray spectroscopy (EDS) (2 marks)

Apart from SE and BSE images, it is also possible to determine the chemical composition of a material using SEM equipped with EDS. Three scan modes in EDS, including line scan, point scan and area scan can be used to obtain the element's profile within the samples. After the scanning, the atomic percent and weight percent of the sample can be obtained. Based on the characteristic x-ray spectra and data given below, 1) briefly describe how the EDS works out the chemical composition; 2) which scan mode gives the most reasonable information of the composition in this particular case? Why?

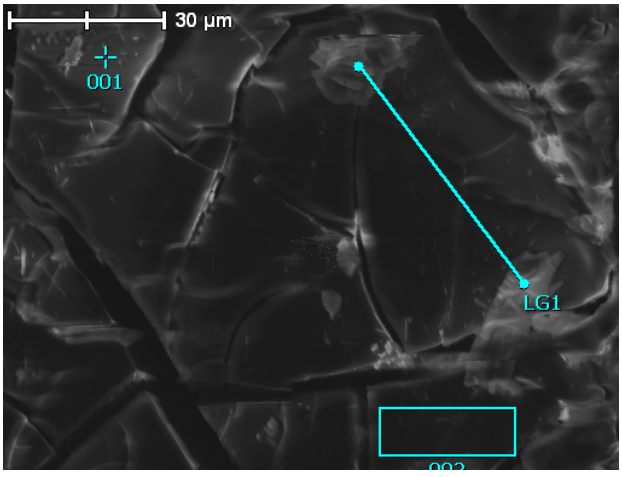
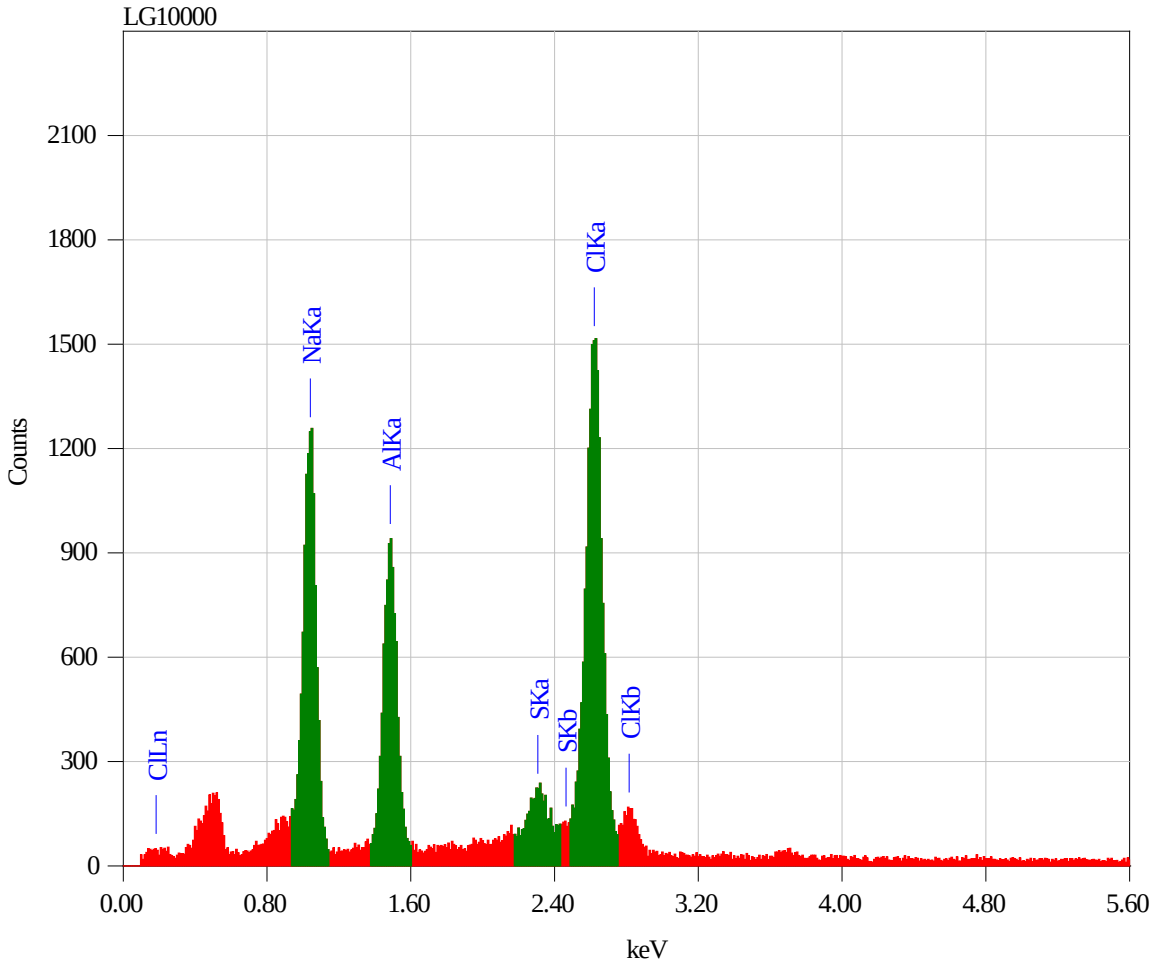
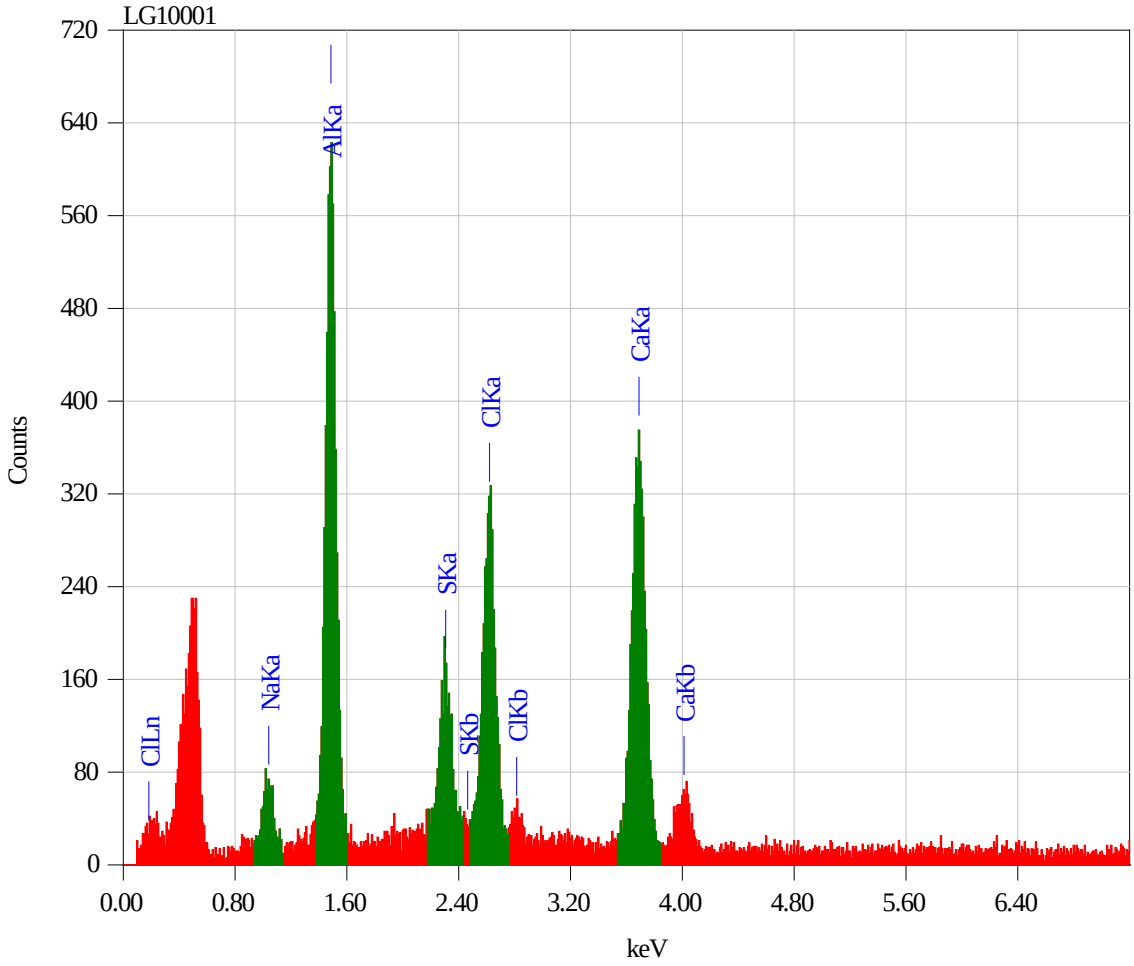


Figure 5, point, line and area scan on the unknown substance



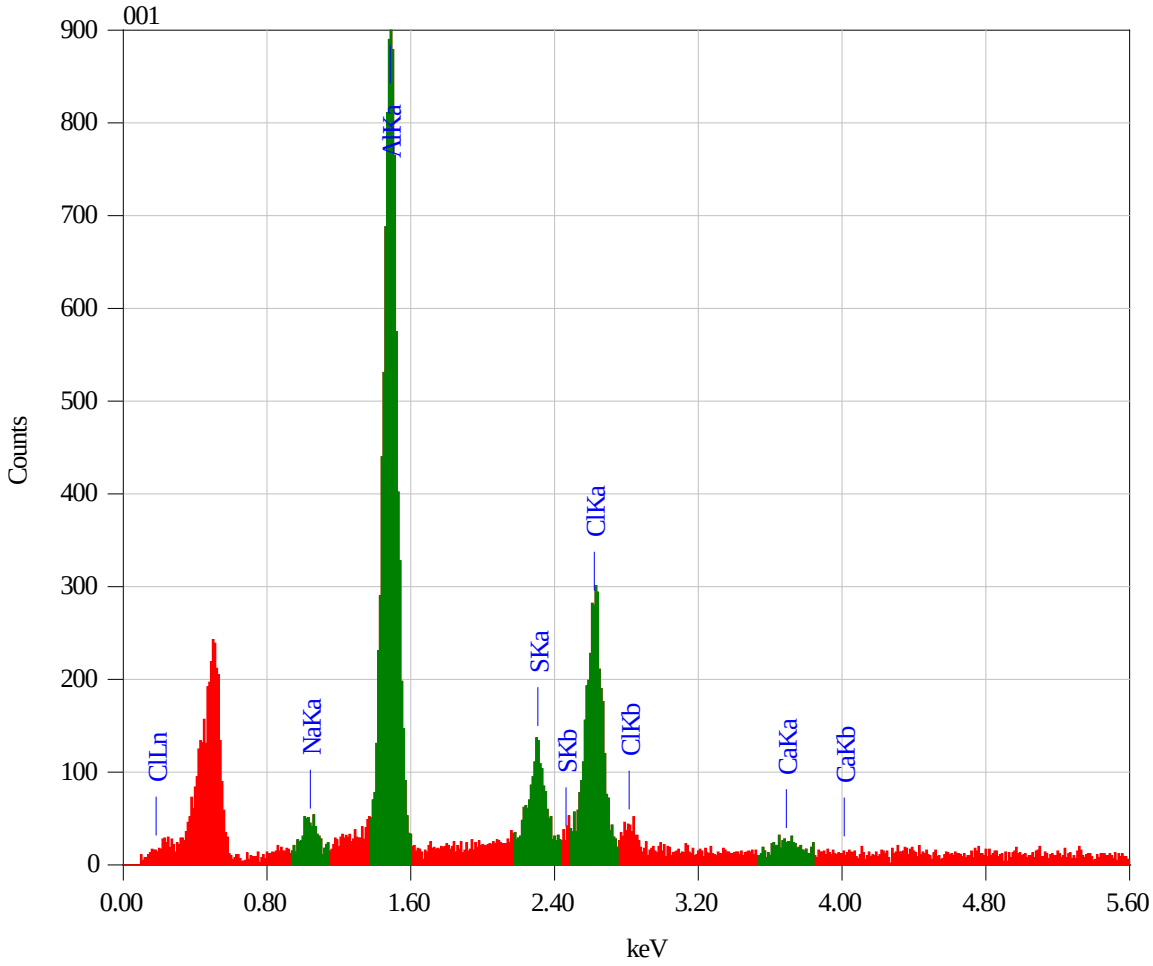
Element	(keV)	mass%	Error%	At%
Na	1.041	31.12	0.12	38.68
Al	1.486	21.73	0.13	23.01
S	2.307	3.65	0.11	3.25
Cl	2.621	43.5	0.13	35.06

Table 3.1: Result of the LG1 line scan



Element	(keV)	mass%	Error%	At%
Na	1.041	4.74	0.32	6.70
Al	1.486	29.99	0.22	36.14
S	2.307	9.27	0.22	9.40
Cl	2.621	22.00	0.26	20.17
Ca	3.690	34.01	0.37	27.59

Table 3.2: Result of the 001 point scan



Element	(keV)	mass%	Error%	At%
Na	1.041	3.15	0.38	4.08
Al	1.486	53.05	0.29	58.45
S	2.307	10.55	0.40	9.78
Cl	2.621	31.37	0.45	26.30
Ca	3.690	1.87	0.65	1.39

Table 3.3: Result of the 002 area scan