UNIVERSITY OF GHANA

BSc (ENG) MATERIALS SCIENCE AND ENGINEERING

END OF FIRST SEMESTER EXAMINATIONS: 2015/2016

DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING

MTEN 309: MATERIALS ANALYSIS TECHNIQUES (3 CREDITS)

TIME ALLOWED: Two and half (2 ½) HRS

Answer all Questions (*70 marks*)

1.

a) Give two (2) main reasons why characterization instruments based on electron beam and x-ray radiation are carried out in an ultrahigh vacuum chamber with a pressure of 10^{-9} torr or below.

b) Explain briefly why the Auger electron spectroscopy cannot be used to detect hydrogen and helium in a sample.

c) Both X-ray photoelectron spectroscopy (XPS) and the Auger electron spectroscopy (AES) are characterization tools that analyses electrons emitted from the surface of materials in an ultra-high vacuum chamber. Explain the mode of electron emission process in each instrument.

d) During an XPS characterization, an x-ray radiation emanating from a magnessium (Mg) Kα source strikes a sample resulting in the emission of photoelectrons. What is the kinetic energy of a photoelectron emitted from the surface of the sample if the binding energy of the atomic orbital from which the electron originates is 950 eV. (Mg K_α radiation = 1253.6 eV).

20 marks

2.

a) The x-ray diffraction pattern of gold thin film was measured with x-ray radiation of wavelength of 0.15418 nm from a copper Kα source. The first order Bragg diffraction peak

was found at an angle of (2θ) 50.5 degrees. Calculate the spacing between the diffracting planes in the gold films.

b) The x-ray diffraction pattern obtained from a powder sample revealed two (2) peaks oriented along the (111) and (200) directions at diffraction angles of 2θ = 30 and 45 degrees respectively. Assuming the broadening of the diffracted peaks is due to the grain sizes (dimensionless shape factor is 0.9), calculate the grain sizes oriented in the (111) and (200) directions using the Scherrer relation if their full width at half maxima (FWHM) are 0.5° and 0.4° respectively. The wavelength of the X-ray radiation used is 0.154 nm.

c) Describe the contact and non-contact modes of the Atomic Force Microscope (AFM) during the measurement of the surface roughness of a thin film on glass substrate.

d) In their operational mode, state the main difference between an energy dispersive spectrometry (EDS) and wavelength dispersive spectrometry (WDS).

20 marks

3.

a) What is thermal analysis? Write down three (3) thermal analytic methods and their corresponding measurable properties.

b) In a Secondary Ion Mass Spectrometer (SIMS) operation, an ion beam after interacting with the sample surface is directed to move in a magnetic field with an accelerating voltage of 55 volts. If the magnetic field strength is 15 Wb / m^2 and the charge-to-mass ratio is 0.3, calculate the radius of curvature of the ion beam.

c) Write down the formation of four (4) different signals when a collimated elecctron beam is accelerated through a vacuum to strike a sample during an electron probe microanalysis (EPMA) experiment.

d) Write down two (2) advantages and (2) disadvantages of the secondary ion mass spectroscope (SIMS).

20 marks

4.

a) Describe the mode of formation of images by the scanning electron microscope (SEM) when it is operated in backscattered electron and secondary electron modes respectively.

b) The magnification of the objective lens of a compound microscope is 20X. If the magnification of the ocular lens is 5X, calculate the total magnification of the compound microscope.

c) State two (2) advantages the Atomic Force Microscope (AFM) has over electron microscopes (SEM and TEM).

10 marks