UNIVERSITY OF GHANA

BSc. (Eng) MATERIALS SCIENCE AND ENGINEERING

FIRST SEMESTER EXAMINATIONS 2018/2019

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MTEN 309: MATERIALS ANALYSIS TECHNIQUES (3 CREDITS)

TIME- 3HRS

ANSWER ALL QUESTIONS

1.

a)

(i) Briefly explain the term Spectroscopy **[2 marks]**

(ii) State four (4) benefits of the use of X-ray Fluorescence in industry? **[4 marks]**

(iii)Distinguish between Wavelength Dispersive X-ray Florescence (WDXRF) and Energy Dispersive X-ray Florescence (EDXRF). **[4marks]**

b) The ultraviolet spectrum of benzonitrile shows a primary absorption band at 224 nm and a secondary band at 271 nm.

(i) If a solution of benzonitrile in water with a concentration of 1×10^{-4} molar placed in a cuvette with cell length of 1 cm shows an optical absorption band at a wavelength of 224 nm and maximum absorbance of 1.30, what is the molar absorptivity of this absorption band? **[2marks]**

(ii) If for the same solution, the absorption band is observed at $\lambda = 271$ nm, what will be the absorbance reading (e = 1000) and the intensity ratio, I_0/I? **[2 marks]**

c)

(i) In performing a full range UV-Vis-NIR spectroscopy, different light sources are activated at various stages in the electromagnetic spectrum. State the light sources and their corresponding wavelength ranges during a full-scale UV-Vis-NIR routine scans. **[6 marks]**

(ii) With the aid of mathematical expressions, briefly explain the Beer-Lambert law. **[5 marks]**

Examiner: Dr. David Dodoo-Arhin

32

2.

a) Briefly discuss the four (4) main categories of materials characterisation techniques. **[4 marks]**

b) 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. **[4 marks]**

c) Briefly describe the principles of Transmission Electron Microscopy (TEM). **[6 marks]**

d)

(i) Auger Electron Spectroscopy (AES) is a non – destructive core level electron spectroscopy for semi-quantitative determination of the elemental composition of surfaces, thin films, and interfaces. With the aid of a diagram, explain the KL_2L_3 auger transition showing clearly the ionization, relaxation and emission steps involved in the auger process. **[6 marks]**

(ii) Can the Auger electron spectroscopy be used to detect hydrogen and helium in a sample? Give reasons for your choice. **[5 marks]**.

3.

a) Briefly explain the term Thermal Analysis. **[2marks]**

b) Discuss the following terms in relation to thermal analysis: thermogravimetric analysis (**TGA**), differential scanning calorimetry (**DSC**), and differential thermal analysis (**DTA**). **[6marks]**

c) In using thermal analysis as a characterisation tool, state and explain four (4) physical limitations that can affect the heating process on your sample. **[8marks]**

d) Briefly discuss the principles of Infrared spectroscopy in materials characterisation. Use diagrams where appropriate. **[10marks]**

4.

a) Given that the path difference between the incident and the reflected x-rays is AB – AD = nλ as shown in figure 1, prove the validity of the Bragg's Law. **[5 marks]**

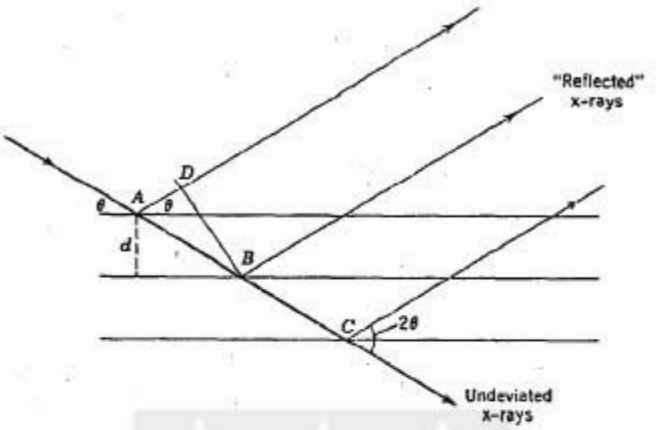

Figure 1

b) The following X-ray diffraction peak position data (expressed as 2θ°) were generated from a specimen irradiated with silver (Ag) Kα radiation: 14.10°; 19.98°; 24.57°; 28.41°; 31.85°; 34.98°; 37.89°; 40.61°. Take $\lambda_{Ag\,K\alpha} = 0.574\text{Å}$; $\lambda_{L\alpha}^{-1} = \frac{5}{36}R(Z-7.4)^2$, where $R = 1.1 \times 10^7 m^{-1}$ and $Z_{Ag} = 47$

(i) Determine the crystal structure of the specimen. **[10marks]**

(ii) Calculate the lattice constant, **a**. **[3 marks]**

(iii) Assuming that the crystal is a pure metal, calculate the atomic radius on the basis of the hard-sphere approximation. **[3 marks]**

(iv) If instead of using Ag K_α radiation, silver (Ag) L_α radiation was used to illuminate the specimen, at what 2θ angle would the first reflection be? **[4 marks]**