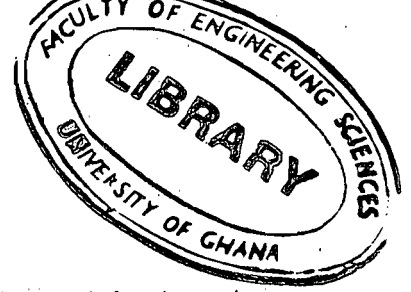




UNIVERSITY OF GHANA

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BSc. (Eng) MATERIALS SCIENCE AND ENGINEERING

FIRST SEMESTER EXAMINATIONS 2016/2017

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MTEN 309: MATERIALS ANALYSIS TECHNIQUES (3 CREDITS)

TIME- 3HRS

ANSWER ALL QUESTIONS

1.

- a) Briefly discuss the four (4) main categories of materials characterisation techniques. [8marks]
- b) State 3 analytical tools under each category of materials characterisation technique discussed above. [3marks]
- c) What are x-rays? Briefly explain how x-rays are produced [6 marks]
- d) In materials science, x-ray diffraction is an important characterisation tool for microstructure analysis. The Bragg's law is the prominent underlining principle governing the diffraction by x-rays.

(i) Briefly discuss the Bragg's law for x-ray diffraction. [4marks].

(ii) Using the equation of the Bragg's law and also given that the relation between the interplanar distance of a cubic crystal and its interatomic distance is

$$d_{\text{Cubic}} = \frac{a}{\sqrt{h^2 + k^2 + l^2}} \text{ show that } a^2 = \frac{\lambda^2}{4\sin^2 \theta} (h^2 + k^2 + l^2) \quad [10 \text{ marks}]$$

2.

- a) As a Materials Science Engineer in the research and development laboratory of a manufacturing company, state four (4) reasons why you will undertake materials characterisation. [4marks]
- b) Explain the term spectroscopy. [2marks]

(i) In using UV-Vis-NIR spectroscopy as a characterisation tool, what material property will you be investigating on your samples? [2marks]

(ii) 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. [6marks]

c) With the aid of mathematical expressions briefly explain the Beer-Bouguer-Lambert law. [5marks]

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

3.

a) Using copper radiation of wavelength $\lambda = 1.5405 \text{ \AA}$, Aluminium powder gives a diffraction pattern that yields the following eight large d-spacings: 2.338 \AA , 2.024 \AA , 1.431 \AA , 1.221 \AA , 1.169 \AA , 1.0124 \AA , 0.9289 \AA and 0.9055 \AA . Aluminium has a cubic close packed structure and atomic weight of 26.98.

(i) Index the diffraction data. [10marks]

(ii) Calculate the unit cell parameter. [5 marks]

(iii) Calculate the density of aluminium. [5 marks]

b) Explain the term X-ray photoelectron spectroscopy (XPS) and give 2 applications in which XPS is applied as a characterisation technique. [5marks]

4.

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 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]