UNIVERSITY OF GHANA

BSc. (Eng) MATERIALS SCIENCE AND ENGINEERING

FIRST SEMESTER EXAMINATIONS 2017/2018

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MTEN 309: MATERIALS ANALYSIS TECHNIQUES (3 CREDITS)

TIME- 3HRS

ANSWER ALL QUESTIONS

1.

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)

(i) Explain the term spectroscopy. [2marks]

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

(iii) 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-Lambert law. [5marks]

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

2.

a) Briefly discuss the four (4) main categories of materials characterisation techniques. [8marks]

b) State three (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]

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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 it's interatomic distance is $d_{Cubic} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$. Show that $a^2 = \frac{\lambda^2}{4\sin^2\theta}(h^2 + k^2 + l^2)$ **[10 marks]**

3.

a) Using copper radiation of wavelength $\lambda = 1.5405$ Å, Aluminium powder gives a diffraction pattern that yields the following eight large d-spacings: 2.338 Å, 2.024 Å, 1.431 Å, 1.221 Å, 1.169 Å, 1.0124 Å, 0.9289 Å and 0.9055 Å. 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 two (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 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]**