CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE

CHIN 312: INTRODUCTION TO MATERIAL SCIENCE

STREAMS: BSc **TIME: 2 HOURS**

DAY/DATE: TUESDAY 19/12/2023 **11.30 P.M. – 1.30 P.M.**

INSTRUCTIONS:

- **Answer question one and any other two questions**

QUESTION ONE (30 MARKS)

a) Briefly discuss the following materials

i) Metals (2 marks)

ii) Ceramics (2 marks)

iii) Polymers (2 marks)

iv) Composites (2 marks)

b) Compute the percent ionic character (% IC) of the interatomic bond that forms between carbon and hydrogen and comment on the bonding. (Electronegativities for C=2.5 and H=2.1) (3 marks)

c) Differentiate between crystalline and non-crystalline or amorphous materials (2 marks)

d) Discuss the Body Centred Cubic crystal structure (BCC) and draw the hard-sphere unit cell representation for the BCC (3 marks)

e) Copper has an atomic radius of 0.128 nm, an FCC crystal structure and an atomic weight of 63.5 g/mol. Complete its theoretical density and compare the answer with its measured density of 8.94 g/cm^3 (5 marks)

f) i) Using a suitable diagram, define a unit cell, showing its coordinate axes, axial lengths and interaxial angles (4 marks)

ii Give two crystal system giving their axial relationship and interaxial angles (3 marks)

g) Using a suitable equation define the linear density (2 marks)

QUESTION TWO (30 MARKS)

a) Explain the term:

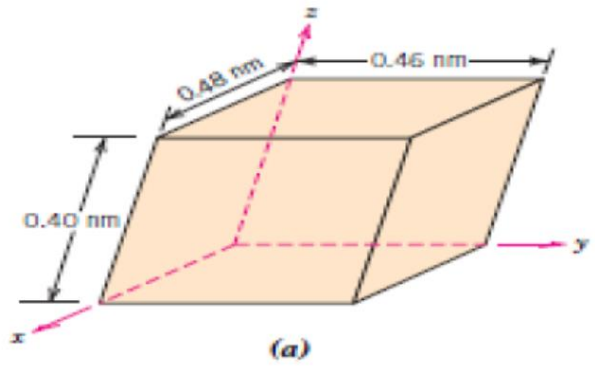
i)Biomaterials (2 marks)

ii) Smart materials (2 marks)

iii) Single crystal (2 marks)

iv)Polycrystalline materials (2 marks)

b) For a unit cell shown in the accompanying diagram; locate the points having coordinates ¼ 1 ½ (5 marks)



(a)

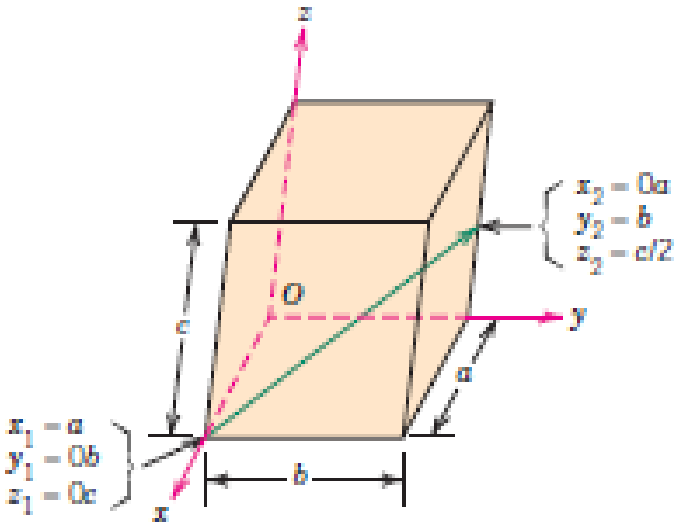
c) Using a suitable diagram differentiate between a Frenkel and a Schottky defects (3 marks)

d) Explain the term solid solution (2 marks)

e) Differentiate between substitutional and interstitial impurity point defects (2 marks)

QUESTION THREE (20 MARKS)

a) Determine the indices for the direction shown in the figure below (6 marks)



b) Discuss two Hume-Rothery rules (4 marks)

c) Define a dislocation (1mark)

d) Differentiate between an edge and a screw dislocation (3 marks)

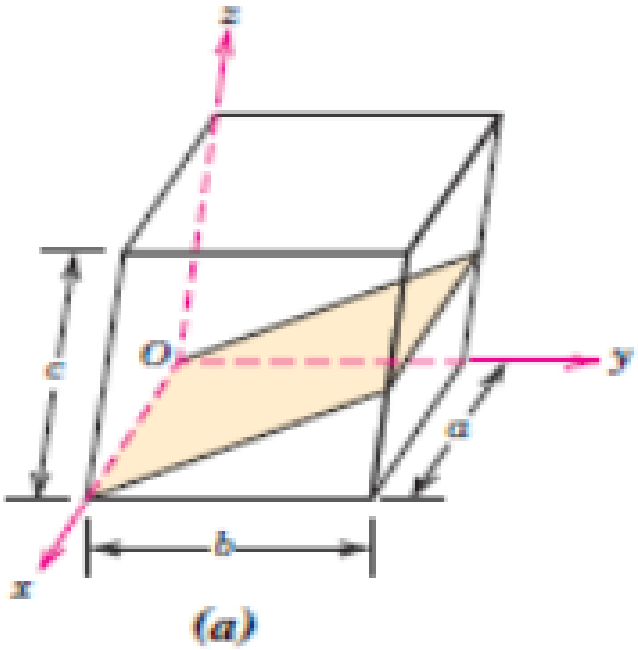
e) i)Define diffusion flux J using a suitable equation (1 mark)

ii) Using a suitable equation, give the Ficks first law of Diffusion (1 mark)

iii) A plate of iron is exposed to a carburizing (carbon-rich) atmosphere on one side and a decarburizing (carbon deficient) atmosphere on the other side at 700◦ C(1300◦F). If a condition of steady state is achieved, calculate the diffusion flux of carbon through the plate, if the concentrations of carbon at positions 5 and 10 mm (5×10^{-3} and 10^{-2} M), beneath the carburizing surface are 1.2 and 0.8 kg/m^3 respectively. Assume a diffusion coefficient of 3×10^{-11} m^2/s at this temperature (4 marks)

QUESTION 4 (20 MARKS)

a) Determine the miller indices for the plane shown in the following sketch (5 marks)



(a)

b) Define a crystalline defect (2 marks)

c) i) Using a suitable equation, define the equilibrium number of vacancies for a given material and define the terms (3 marks)

ii) Calculate the equilibrium number of vacancies per cubic meter for copper at 1000 ◦C. The energy for vacancy formation is 0.9 Ev/atom; the atomic weight and density (at 1000◦C) for copper are 63.5 g/mol and 8.40 g/cm^3 respectively (5 marks)

d) i) Define diffusion in materials (1mark)

ii) Give two conditions for diffusion in solid materials (1 mark)

iii) Differentiate between a vacancy diffusion and an interstitial diffusion (3 marks)

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