



DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

University Examinations 2021/2022 Academic Year

FIRST YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF
BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING,
BACHELOR OF SCIENCE IN TELECOMMUNICATION & INFORMATION
ENGINEERING AND BACHELOR OF EDUCATION TECHNOLOGY (ELECTRICAL)

EEE 1204/TIE 1204: MATERIALS SCIENCE

DATE: 16th MAY 2022

TIME: 11.00am – 1.00pm

INSTRUCTIONS

1. This paper contains FIVE questions.
 2. Attempt any THREE questions. All questions carry equal marks.
 3. All symbols have usual meaning unless otherwise stated.
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QUESTION 1 (20 Marks)

- (a) (i) Define an atom. **(1 Mark)**
- (ii) Draw the basic atomic structure diagram of boron, which is element number 5 in the periodic table. **(2 Marks)**
- (iii) In order to understand details of how the electrons are behaving, it is necessary to study electromagnetic radiations. Define the terms electromagnetic radiations, wavelength and wave number. **(3 Marks)**
- (iv) The green light has a wavelength of 535 nm. Calculate the energy of a photon of green light. Take $h = 6.626 \times 10^{-34} \text{ J s}$ and $c = 3.0 \times 10^8 \text{ m/s}$. **(3 Marks)**
- (b) (i) In the electronic structure of the atom, differentiate between the terms orbital and node. **(2 Marks)**
- (ii) In the wave model of an atom, four quantum numbers are found from solving the wave equations. Give names of these numbers and briefly explain what they relate to. **(4 Marks)**
- (c) (i) Briefly explain the term ionization energy and state with reason how it is related to ionization potential. **(2 Marks)**
- (ii) H–H has bond strength of 436 kJ/mol. Explain what happens in the reaction
$$2 \text{ H} \cdot \rightarrow \text{ H}_2$$
and with the aid of a sketch, show the energy levels between the hydrogen atoms and the hydrogen molecule. **(3 Marks)**

QUESTION 2 (20 Marks)

- (a) Briefly explain the following types of bonds.
- (i) Ionic bond
 - (ii) Covalent bond
 - (iii) Metallic bond

(iv) Van Der Waal's bond **(6 Marks)**

(b) (i) Give the chemical equation which will produce Ba^{+2} from BaSO_4 . Explain why doctors still prescribe to patients BaSO_4 despite Ba^{+2} being toxic. **(2 Marks)**

(ii) Give the equation that represents Gibb's Law and explain the terms. Further, explain how you will use the law to determine if a reaction will be spontaneous or not. **(3 Marks)**

(c) (i) With the aid of a neat and well labeled sketch of the molecular orbital energy-level diagram, explain the two principal factors upon which relative energies of molecular orbitals depend. **(6 Marks)**

(ii) Certain rules/principles are to be followed while filling up molecular orbitals with electrons in order to come up with the correct molecular configurations. The most common ones are Aufbau Principle, Pauli's Exclusion Principle and Hund's Rule. Briefly explain the three rules/principles. **(3 Marks)**

QUESTION 3 (20 Marks)

(a) Explain the difference on how copper crystals form as compared to sodium chloride. **(2 Marks)**

(b) (i) Sketch the SCC, FCC, BCC and HCP structures. **(6 Marks)**

(ii) Chromium has a BCC structure while Aluminum has an FCC structure. State which of the two materials is denser and give reason. **(2 Marks)**

(iii) Compare the behavior of BCC metals and FCC metals as far as ductile to brittle transition is concerned. **(2 Marks)**

(c) Some crystallographic planes have a higher density of nodes. Explain the influence of these high density planes on;

(i) surface tension

(ii) microstructural defects. **(3 Marks)**

(d) Explain how and why the following factors affect the resistivity of electrical materials.

(i) Alloying **(2 Marks)**

(ii) Temperature **(2 Marks)**

(iii) Cold working **(1 Mark)**

QUESTION 4 (20 Marks)

(a) Aluminum has largely replaced copper as a conductor in some applications due to specific desirable properties. Mention any three such applications and explain the desirable property in each case. **(3 Marks)**

(b) Briefly explain the following effects.

(i) Thomson effect **(3 Marks)**

(ii) Seebeck effect **(3 Marks)**

- (c) A copper rod extends by 12mm when heated from room temperature to temperature $T^{\circ}\text{C}$, determine the elongation if Brass was heated from room temperature to the same final temperature $T^{\circ}\text{C}$, given that linear coefficient of thermal expansion for copper and Brass are 0.005K^{-1} and 0.0015K^{-1} . **(3 Marks)**
- (d) (i) Calculate the drift velocity of electrons in copper (valence =1) using the following data.
 Data: conductivity of copper $5.98 \times 10^5 (\Omega\cdot\text{cm})^{-1}$; $q = 1.6 \times 10^{-19}\text{C}$; lattice parameter of copper $= 0.36151 \times 10^{-7}\text{cm}$; copper has a FCC structure
(3 Marks)
- (ii) Assuming that all of the valence electrons contribute to current flow, determine the mobility of an electron in copper and the average drift velocity for electrons in a 100 cm copper wire when 10V are applied. **(5 Marks)**

QUESTION 5 (20 Marks)

- (a) Differentiate between paramagnetic materials and ferromagnetic materials. **(3 Marks)**
- (b) A magnetic material such as iron spontaneously divides into separate domains, so as to minimize its internal energy. Briefly explain the following energies that need to be minimized and how the minimization is achieved.
 (i) Magnetostatic energy **(2.5 Marks)**
 (ii) Anisotropy energy **(2.5 Marks)**
- (c) (i) Briefly explain the term piezoelectricity. **(2 Marks)**
 (ii) Differentiate between absolute permeability and permittivity. **(3 Marks)**
- (d) The basic optical properties of materials is either they are transparent, translucent or opaque. However other properties exist which are more important in engineering applications. Explain two such properties and where they find applications. **(4 Marks)**
- (e) When you are looking for a data storage system e.g. in computers, explain any three factors you will consider at the initial stages.