B Sc in EEE, 1st Sem. Date: 06 October 2023 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid-Semester Examination
Course Number: PHY 4121
Course Title: Engineering Physics I

Winter Semester: A.Y. 2022 - 2023
Full Marks: 75
Time: 90 minutes

Please answer according to the order of the questions. There are 3 **(three)** questions. Answer all 3 **(three)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding CO and PO are written in the brackets at right side.

1. a) Explain why Rutherford used the gold foil in the α-particle scattering experiment of discovering the existence positive charges (nucleus) at the center of an atom. (5) (CO1) (PO1)

   b) Describe the modern and established model of an atom and explain why only the outermost electrons of an atom usually participate in bonding to form the molecules/compounds. Distinguish between different types of bonding in terms of forces between particles, states of the matter, electrical conductivity and melting and boiling points. (10+5) (CO2) (PO2)

   c) The transition of electrons between two energy levels emits photons at the middle of the visible range (532 nm). Calculate the energy (*in eV*) of the emitted photons (in case you need the value of Planck's constant, $h = 6.626 \times 10^{-34}\ j\ s$). (05) (CO3) (PO2)

2. a) Write down the major success and drawbacks of classical free electron theory for metals. (05) (CO1) (PO1)

   b) Following the quantum model show that electronic energy can have only the discrete values given by, $E_n = \frac{n^2 h^2}{8mL^2}$ where, the symbols have their usual meanings. (15) (CO2) (PO2)

   c) Calculate the probability of an electron occupying an energy level of *0.05 eV* above and below the Fermi level at *500 K*. (05) (CO3) (PO2)

3. a) Explain the origin of energy bands in solids; hence define the valence band and conduction band for them. (5) (CO1) (PO1)

   b) Find out the expression of carrier concentrations in semiconductors and show that for an intrinsic semiconductor, the position of the Fermi level is at the middle of the bottom of conduction band and top of valence band at absolute zero temperature, i.e., $E_F = \frac{E_C + E_V}{2}$. Here, symbols have their usual meanings. (15) (CO2) (PO2)

   c) The conducting behavior of a p-n junction can be quantified by an equation, $I = I_S\left(e^{\frac{qV}{nk_BT}} - 1\right)$, derived by William Shockley. Illustrate the *I-V* curve according to this equation and also show the variation of reverse saturation current as a function of *V* for different temperatures. (05) (CO3) (PO2)