KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: ~~SPH 423~~ SPC 412

COURSE TITLE: SOLID STATE PHYSICS III

DATE: 23/05/2022 **TIME: 2:00PM-4:00PM**

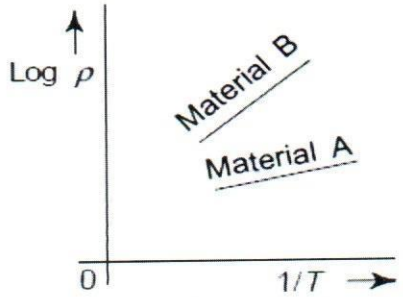
INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

Question One

a) Other than its high resistance, explain how germanium can be identified as semiconductors from siver metal. (2 mks)
b) State one disadvantage of intrinsic semiconductors. (1 mk)
c) Differentiate between *P*-type and *N*-type superconductors. (2 marks)
d) Describe the effect of temperature on the conductivity of a semiconductor (3 marks)
e) Find the conductivity and resistivity of a pure silicon crystal at temperature 300°K. The density of electron hole pair per cc at 300°K for a pure silicon crystal is 1.072×10^{10} and the mobilityof electron μ_n= 1350 cm^2/volt-sec and hole mobility μ_h= 480 cm^2/volt-sec.(3mks)
f) How much donor impurity should be added to pure germanium so that its resistivity drops to 10% of its original value? Determine n and p in a p-type germanium sample whose resistivity is 0.01 ohm-cm, and also find n and p in a N-type silicon sample whose resistivity is 10 Ωcm. Resistivity of pure Ge is 44.6 Ωcm.(4 marks)
g) Figure below shows the plot of log of resistivity versus reciprocal of temperature for two different semiconductors A and B. Assume that mobility is proportional to $T^{-3/2}$,



Which material has wider band gap and why? (4mks)
h) Define the Hall effect. (2 marks)
i) State any four uses of Hall effect. (2 marks).
j) The Hall coefficient of a specimen of doped silicon is found to be 3.66×10^{-4} m^3/°C. The resistivity of the specimen is 8.93×10^{-3} Ωm, assuming single carrier concentration find the mobility and density of charge carrier.(3 marks)
k) Define the following terms as used in superconductivity
   (i) Critical temperature (1 mark)
   (ii) Energy gap (1 marks)
l) Differentiate between Type I and type II superconductors. (2 marks)

Question Two

a) If N_c and N_v denote the density of states in the conduction band and density of states in the valence band, respectively while E_{fi}, E_{fn} and E_{fp} denote energies associated with the Fermi levels in intrinsic, *N*-type and *P*-type semiconductors, respectively, show that

$$E_{fn} - E_{fi} = kT\, ln\frac{n}{n_i}$$

Show a diagrammatic representation of this equation. (10 marks)

b) The conductivity of an intrinsic semiconductor $\sigma_i = n_i e(\mu_n + \mu_p)$ is given by

$$\sigma_i = n_i e(\mu_n + \mu_p)$$

Proceeding from this equation, show that conductivity of intrinsic semiconductor varies exponentially with increase in temperature. (10 marks)

Question Three

a) Starting with the current density $J_{xe} = en\mu_e E_x$ along the x-axis of a rectangular slab, with e as the electron charge, n as the electron number density, μ_e as the electron mobility andE_x as the electric field along the x-axis, show that the Hall coefficient $R_H = \frac{e(n\mu_e^2 - p\mu_h^2)}{\sigma^2}$ where μ_h is the whole mobility and σ is the electric conductivity of the semiconductor. (10 Marks)

b) Using a well labeled diagram, show how the Hall coefficient can be determined from the measurable quantities in a laboratory. Define each quantity clearly and how it can be measured. (10 marks)

Question Four

a) Discuss the characteristic properties of superconductors under the following headlines (10 marks)
   i) Resistivity
   ii) Meissner Effect
   iii) Nergy gap
   iv) Coherence length

b) Derive:
   i) The London's first equation(3 marks)
   ii) The London's second equation(4 marks
   iii) The London's penetration depth (5 marks)

Question Five

a) Show that the dielectric constant for a system of two parallel plates of charge density $+\sigma$ and $-\sigma$ separated a distance *d* by a vacuum of permittivity ε_0, is

$$\varepsilon_r = 1 + \chi_E$$

Where χ_E is the electric susceptibility. (10mks)

b) Discuss point defects in crystalline solids. (10mks)