EASTERN UNIVERSITY, SRI LANKA

SPECIAL DEGREE EXAMINATION IN SCIENCE - 2004/05

Part II

PH 410 SUPERCONDUCTIVITY

Answer ALL Questions

Time: **Two Hours**

1. What do you mean by superconductors? Define the following terms in superconductivity.

   (i) Superconducting transition temperature.

   (ii) penetration depth.

   (iii) Coherence length.

   What do you mean by Type I and Type II superconductors? Give three Type I and Type II superconductors and their superconducting transition temperatures. Briefly explain what do you mean by lower and upper critical fields of Type II superconductors?

2. State Meissner effect in superconductors. The London equation for simple superconductors can be written as

$$\mathbf{J} = -\frac{n_s e^2}{m}\mathbf{A}$$

   The symbols have their usual meanings.

   (i) Using appropriate Maxwell's equations derive the above equation.

   (ii) Derive expressions for the magnetic field inside the superconductor and London penetration depth.

   (iii) A superconductor of thickness $2a$ is placed symmetrically perpendicular to X axis. A uniform magnetic field B_0 is applied along Z axis. Find the magnetic field inside the superconductor.

3. (a) What is meant by Critical field H_c of Type I Superconductors? Roughly represent the variation of H_c with temperature in a graph and write down the approximate parabolic expression for $H_c(T)$.

   (b) When a type I superconductor is in the superconducting state a gradually increasing magnetic field is applied to it. Represent in a graph and explain the variations

      (i) Magnetic flux density inside the superconductor.

      (ii) Magnetization of the superconductor.

4. According to Ginsburg-Landau Theory for superconductors the wave function $\psi(r)$ is treated as the order parameter in the expansion of the free energy F of a superconductor.

$$F = F_n + \alpha \mid \psi(r) \mid^2 + \frac{1}{2}\beta \mid \psi(r) \mid^4$$

For stable superconducting phase find the values of $\psi(r)$ and by choosing the appropriate values for α and β show that

(i) The London penetration depth varies with temperature as

$$\lambda_L \propto \left(1 - \frac{T}{T_c}\right)^{-\frac{1}{2}}$$

(ii) The Critical Magnetic field H_c varies with temperature as

$$H_c \propto 1 - \left(\frac{T}{T_c}\right)^2$$

(iii) The Entropy discontinuity in the transition from superconducting to normal state is

$$S_s - S_n = \mu_0 H_c \frac{dH_c}{dT}$$

The symbols have their usual meanings.