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MANIPAL UNIVERSITY

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DEPARTMENT OF SCIENCES, M.Sc. (Physics)
IV SEMESTER - END SEMESTER EXAMINATIONS, APRIL 2017

SUBJECT: CONDENSED MATTER PHYSICS III PHY708.2

(REVISED CREDIT SYSTEM)

Time: 3 Hours Date: 26 April 2017 MAX. MARKS: 50

Note: (i) Attempt any FIVE full questions

(ii) Assume missing data, if any.

1. A) Quantitatively describe how current is divided between two parallel paths in resistance less networks.
   B) A type II superconducting wire of radius R carries current uniformly distributed through its cross section. If the total current carried by the wire is I, show that the magnetic energy per unit length of the wire is $\mu_o I^2/(16\pi)$.
   C) Prove that the entropy in superconducting state is less than that in normal state. Discuss the construction and working of a superconducting cryotron. **[2+3+5]**

2. A) What are the assumptions of London's theory of superconductivity? Derive the expression for penetration depth when an external magnetic field is applied to a superconductor. What are the limitations of London's theory?
   B) Prove the expression of the temperature dependence of specific heat in a superconducting sample around the superconducting transition temperature. Using necessary thermodynamics derive Rutger's formula. With necessary illustrations, discuss the magnetic behavior for a perfect conductor and a superconductor. **[5+5]**

3. A) What are the assumptions of Ginzburg – Landau theory? Derive the expression for critical magnetic field and compare with the empirical formula of critical magnetic field. Discuss how an order parameter is introduced and hence derive the G.L. equations.

   B) If a current is maintained in a superconducting ring for 2.5 years with no observed loss. If the inductance of the ring is 3.14×10^{-8} H and the sensitivity of the experiment is 1 part in 10^9, determine the maximum resistance of the ring. **[6+4]**

4. A) Give an account of the formation of Cooper pairs using electron-phonon interaction. Consider a pair of Cooper pairs and write down the Hamiltonian of the system. Hence show that it is possible for a pair of electrons to have bound state irrespective of the smallness of the attractive interaction between them.

B) Using BCS theory, derive the expression for ground state energy of Cooper pairs.

[4+6]

5. A) What is an electron pair wave? Derive the expression for fluxon. Show how one can use pendulum analogy to explain Josephson tunneling.

B) Give a brief account of the discovery of high temperature superconductors. Draw the unit cell structure of $YBa_2Cu_3O_7$ compound. Discuss various substitutions of elements at different sites and deliberate the importance of copper site. **[5+ 5]**

6. A) What is superfluidity? Discuss the phase diagram of He-3 and He-4.

B) What is the Ehrenfest's classification of phase transitions? Discuss its drawbacks. Explain how these drawbacks are taken care by modern classification scheme. **[5+5]**