KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2009/2010 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHYS 411

COURSE TITLE: SOLID STATE PHYSICS

STREAM: SESSION VII

DAY:

TIME:

DATE:

INSTRUCTIONS:

- **Part I: Question 1 is compulsory and carries 30 marks.**
- **Part II: Each question carries 20 marks. Attempt any two questions.**

PLEASE TURN OVER

PART I: QUESTION 1 IS COMPULSORY AND CARRIES 30 MARKS.

QUESTION 1

(a) Use appropriate arguments to prove that the classical value of the specific heat of solids capacity at constant volume is given by $3R$ near room and at higher temperatures. State any assumptions made. (6 marks)

(b) Define the terms paramagnetism, ferromagnetism and diamagnetism. Indicate the sign and typical order or size of the magnetic susceptibility associated with each case. Name a an example materials exhibiting this property in each case (9 marks)

(c) Describe with relevant diagrams the following terms used to identify imperfections in crystals: Schottky defects, Frenkel defects, H-centres and F-centres. (8 marks)

(d) Define the phenomenon of superconductivity and state the conditions under which it occurs. Mention the latest development in this area with regard to the temperature at which this phenomenon occurs. (4 marks)

(e) Describe three mechanisms by which polarization may occur. (3 marks)

PART II: EACH QUESTION CARRIES 20 MARKS. ATTEMPT ANY TWO QUESTIONS.

QUESTION 2

(a) Explain fully the behaviour of a ferromagnetic material under the influence of an external field with regard to the hysteresis curve. (14 marks)

(b) Briefly describe magnetically hard and soft materials in both cases indicating possible applications. (6 marks)

QUESTION 3

(a) Name and describe, using relevant diagrams, the phenomenon which asserts that a superconductor is a perfect diamagnet. (6 marks)

(b) (i) According to London's theory the current density is defined as

$$\acute{J} = -\frac{1}{\mu\lambda_L^2}\acute{A},$$

where λ_L and A are the London's penetration depth and magnetic vector potential, respectively. Show that the magnetic field induction obeys the equation

$$\nabla^2 \acute{B} = \frac{B}{\lambda_L^2}.$$

(Hint: use an appropriate vector identity and one of Maxwell's equations) (10 marks)

(ii) How does the solution of the equation in (i) account for this phenomenon? (2 marks)

(iii) Name two applications for superconductors (2 marks)

QUESTION 4

(a) (i) Discuss the Kronig-Penny model stating clearly the problem being solved, the results and the implications in trying to address the inadequacies of the Drude model in explaining the properties of solids (7 marks)

(ii) Use energy band diagrams to differentiate between a semiconductor, an insulator and a metal. (6 marks)

(b) Provide relevant arguments and come up with an expression for the effective mass of charge carriers in a periodic potential. Are these arguments of classical, quantum or semi-classical in nature? (7 marks)