UNIVERSITI SAINS MALAYSIA

KSCP Semester Examination
Academic Session 2004/2005

May 2005

ZCT 307E/3 - Solid State Physics I
[Fizik Keadaan Pepejal I]

Duration: 3 hours
[Masa : 3 jam]

Please check that the examination paper consists of **THREE** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

Instruction: Answer all **SIX** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

*[**Arahan**: Jawab kesemua **ENAM** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

1. Plot an experimental graph of specific heat C_v versus temperature (Show all the physical parameters on the graph) of a typical solid. Explain the failure of the classical law on the basis of Debye's model.
[Surihkan graf eksperimen haba spesifik C_v lawan suhu bagi pepejal tipikal. Jelaskan kegagalan hukum klasik berdasarkan model Debye].

(15/100)

2. The specific heat of diamond at 20 °K is 2.45 joule $kmol^{-1}kelvin^{-1}$. Calculate the highest lattice frequency involed in the Debye theory.
[Haba tentu berlian pada 20°K adalah 2.45 joule $kmol^{-1}$ $kelvin^{-1}$. Hitung frekuensi kekisi tertinggi dalam theory Debye].

(10/100)

3. Discuss how Sommerfeld quantum theory of free electrons explain the failure of the classical theory pertaining to the specific heat of solid.
[Bincangkan bagaimana theory kuantum Sommerfeld menjelaskan kegagalan teori klasik berkaitan haba tentu pepejal].

(15/100)

4. State the nature of the Fermi distribution function (plot the required graph). How does it varies with temperature?
[Nyatakan sifat fungsi taburan Fermi (surihkan graph yang bersesuaian). Bagaimanakah ianya berubah terhadap suhu?].

(10/100)

5. (a) The equation below is derived from the Kronig-Penney Model for an electron in a periodic field
[Dari model Kronig-Penney persamaan berikut telah diterbitkan]

$$P\frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka$$

where *[di mana]* $P = \frac{mV_o ba}{\hbar^2}$ and *[dan]* $\alpha^2 = \frac{2mE}{\hbar^2}$

(i) Explain the physical meaning of all the terms in the equation above.
[Jelaskan maksud fizikal bagi semua sebutan persamaan di atas.]

(ii) Plot a graph of $P\frac{\sin \alpha a}{\alpha a}+\cos \alpha a$ versus αa. Discuss what you can deduce from the graph.
[Plot graf $P\frac{\sin \alpha a}{\alpha a}+\cos \alpha a$ *lawan* αa. *Bincang apa yang anda perolehi dari graf tersebut.]*

(b) Show from the E-k graph that materials can be classified into conductors, insulators and semiconductors.
[Dari graf E-k bagaimanakah anda boleh mengkelaskan bahan konduktor, penebat dan semikonduktor]

(30/100)

6. (a) Show that for the case of intrinsic semiconductors, the carrier concentration is given by
[Tunjukkan bagi kes semikonduktor intrinsik, kepekatan pembawa diberi oleh]

$$n = p = n_i = 2(\frac{k_B T}{2\pi\hbar^2})^{3/2}(m_e m_h)^{3/4} e^{-E_g/2k_B T}$$

(b) The gap for an intrinsic semicondutor is E_g = 0.7 eV at room temperature (300 K). Determine the position of the Fermi level at 300 K. Also calculate the density of holes and electrons at 300 K. Given $m_p^* = 6m_e^*$
[Jurang tenaga bagi sesuatu semikonduktor intrinsik adalah E_g = *0.7 eV pada suhu bilik (300 K). Tentukan kedudukan paras Fermi pada 300 K. Juga hitung ketumpatan lohong dan elektron pada 300 K.*
Diberi $m_p^* = 6\, m_e^*$*]*

(20/100)

- ooo O ooo -