UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2004/2005

October 2004

ZCT 307E/3 - Solid State Physics I

[Fizik Keadaan Pepejal I]

Duration : 3 hours
[Masa : 3 jam]

Please check that this 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.]*

Instructions: Answer all **FOUR** (4) questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

*[**Arahan:** Jawab kesemua **EMPAT** (4) soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

1. (a) Discuss the reasons for the failure of Dulong and Petit's law to predict the specific heat at low temperatures. Why should the law be valid at high temperatures?

[(a) Bincang mengapa hukum Dulong dan Petit tidak mampu meramal haba tentu pada suhu rendah. Kenapa hukum itu berlaku pada suhu tinggi?]

(b) Discuss how Debye's theory managed to overcome the shortcomings of the classical theory.

[(b) Bincangkan bagaimana teori Debye mengatasi masalah di atas.]

(c) Debye temperature of carbon is 1850 K. Compute the Debye frequency involved in the Debye theory.

[(c) Suhu Debye bagi karbon adalah 1850 K. Tentukan frekuensi Debye bagi kes teori Debye.]

(20/100)

2. (a) Discuss the failure of the classical free electron model with special reference to the specific heat of metals.

[(a) Bincangkan kegagalan model klasik elektron bebas berasaskan haba tentu logam.]

(b) Explain how Sommerfeld modified the free electron theory to remove this shortcomings.

[(b)] Jelaskan bagaimana model Sommerfeld mengubahsuai teori elektron bebas bagi menjelaskan perkara di atas.]

(c) Estimate the fractions of electrons excited about the Fermi level at room temperature (T = 300 K). E_F = 3.1 eV for Na.

[(c) Tentukan pecahan elektron yang teruja sekitar paras Fermi pada suhu bilik (T = 300 K). E_F = 3.1 eV bagi Na.]

(25/100)

3. (a) The Equation below is derived from the Kronig-Penney Model for an electron in a periodic field,

[(a) Persamaan berikut telah diterbitkan daripada model Kronig-Penney,]

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

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

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(i) Explain the physical meaning of all the terms in the equation above.
[(i) 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.

[(ii) 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.
[(b) Dari graf E-k bagaimanakah anda boleh mengkelaskan bahan konduktor, penebat dan semikonduktor]

[c] Prove that for the Kronig Penney model the energy of the lowest energy band at k = 0 is $E = \frac{\hbar^2 P}{ma^2}$
[(c) Buktikan dari model Kronig-Penney bahawa tenaga bagi jalur terendah $k = 0$ *adalah* $E = \frac{\hbar^2 P}{ma^2}$ *]*

(30/100)

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

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

[b] Mobilities of electrons and holes in a sample of intrinsic germanium at 300 K are 0.36 $m^2V^{-1}s^{-1}$ and 0.17 $m^2V^{-1}s^{-1}$ respectively. If the conductivity of the specimen is 2.12 $\Omega^{-1}m^{-1}$, compute the forbidden energy gap.
[(b) Kelincahan elektron dan lohong bagi sampel germanium intrinsik pada suhu 300 K adalah 0.36 $m^2V^{-1}s^{-1}$ *dan 0.17* $m^2V^{-1}s^{-1}$ *secara berturutan. Jika kekonduksian germanium adalah 2.12* $\Omega^{-1}m^{-1}$ *hitung jurang tenaga germanium.]*

(25/100)

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