UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2003/2004

September – Oktober 2003

ZCT 307E - Fizik Keadaan Pepejal I

Masa : 3 jam

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

Jawab kesemua EMPAT soalan. Pelajar dibenarkan menjawab semua soalan dalam Bahasa Inggeris ATAU Bahasa Malaysia ATAU kombinasi kedua-duanya.

Diberi: $e=1.60 \times 10^{-19}C$, $m_e=9.11 \times 10^{-31}kg$, $N_A=6.02 \times 10^{+23}mol^{-1}$, $K_B=1.38 \times 10^{-23}JK^{-1}$

1. (a) Nyatakan hukum Dulong dan Petit. (3/25)

   (b) Bincang variasi muatan haba tentu bagi pepejal terhadap suhu. (5/25)

   (c) Jelaskan mengapa hukum Dulong dan Petit tidak berlaku pada suhu rendah. (10/25)

   (d) Haba tentu kekisi pada suhu rendah bagi tembaga adalah $C_V = 4.6 \times 10^{-2}T^3$ J/kmol-K. Tentukan suhu Debye bagi tembaga. (7/25)

2. (a) Hitung sumbangan elektron bebas terhadap haba tentu logam berasas teori klasik elektron bebas (model Drude). (4/30)

   (b) Apakah hasil [a] setuju dengan eksperimen? Bincangkan. (5/30)

   (c) Takrifkan tenaga Fermi. (3/30)

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(d) Terbitkan suatu hubungan am tenaga Fermi elektron dalam pepejal pada suhu sifar Kelvin.

(5/30)

(e) Tunjukkan pada 0 K tenaga purata elektron ialah 3/5 tenaga Fermi.

(5/30)

(f) Tunjukkan jarak gelombang berhubungkait dengan elektron bertenaga Fermi adalah

$$\lambda_F = 2[\frac{\pi}{3n}]^{1/3}$$

(8/30)

3. (a) Rajah 1 menunjukkan variasi tenaga, halaju, jisim berkesan dan f_k sebagai fungsi k mengikut teori jalur. Bincangkan setiap variasi menurut teori jalur pepejal dan bandingkan dengan model elektron bebas.

(15/25)

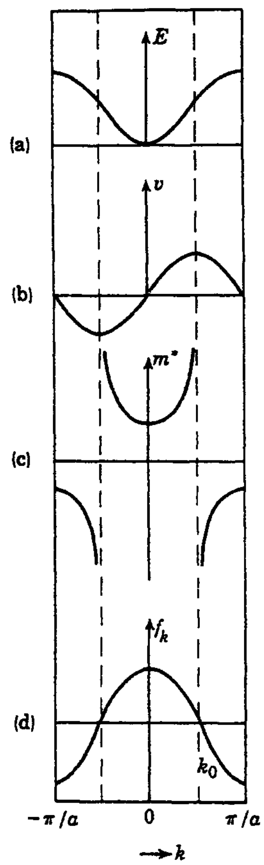

Fig. 1. Energy, velocity, effective mass and f_k as function of k. The dashed lines correspond to the inflection points in the $E(k)$ curve.

(b) Dari (a) bincangkan bagaimana teori jalur pepejal dapat menjelaskan mengapa bahan-bahan tertentu mempunyai koefisien Hall yang positif.

(10/25)

4. (a) Ada ahli sains berpendapat wujud hanya dua jenis bahan, logam dan semikonduktor. Beri penjelasan ringkas berkaitan pendapat ini.

(8/20)

(b) Dalam suatu semikonduktor intrinsik, jisim berkesan elektron adalah $0.07m_e$ dan lohong adalah $0.4m_e$, di mana m_e adalah jisim rehat elektron. Kelincahan electron $\mu_e = 0.39\ m^2V^{-1}s^{-1}$ dan lohong $\mu_p = 0.190\ m^2V^{-1}s^{-1}$ dan jurang tenaga $E_g = 0.7$ eV. Hitung kepekatan elektron dan lohong pada 300 K dan tentukan kekonduksian bahan ini.

(12/20)

TERJEMAHAN

UNIVERSITI SAINS MALAYSIA

First Semester Examination
2003/2004 Academic Session

September - October 2003

ZCT 307E - Solid State Physics I

Time : 3 hours

Please check that the examination paper consists of **SIX** printed pages before you commence this examination.

Answer all FOUR questions. Students are allowed to answer all questions in English OR Bahasa Malaysia OR a combination of both.

Given: $e=1.60x10^{-19}C$, $m_e=9.11x10^{-31}kg$, $N_A=6.02x10^{+23}mol^{-1}$, $K_B=1.38x10^{-23}JK^{-1}$

1. (a) State Dulong and Petit's law. (3/25)

   (b) Discuss the variation of specific heat capacity of solids with temperature. (5/25)

   (c) Explain the departure from the law (Dulong and Petit's law) at lower temperatures. (10/25)

   (d) The lattice specific heat at low temperature for copper is $C_v = 4.6 \times 10^{-2}T^3$ J/kmol-K. Estimate the Debye temperature for copper. (7/25)

2. (a) Calculate the contribution made by free electrons to the specific heat of metals on the basis of the classical free electron theory (Drude's model). (4/30)

   (b) Does the result in (a) agrees with experiment ? Discuss. (5/30)

   (c) Define Fermi energy. (3/30)

(d) Obtain a general expression for the Fermi energy of electrons in solids at zero degree Kelvin.

(5/30)

(e) Show that at 0 K the average energy of the electron is 3/5 of the Fermi energy.

(5/30)

(f) Show that the wave length associated with an electron having an energy equal to the Fermi energy is given by,

$$\lambda_F = 2[\frac{\pi}{3n}]^{1/3}$$

(8/30)

3. (a) Figure 1 shows the variation of energy, velocity, effective mass and f_k as function of k according to the band theory. Discuss each variation in accordance to the band theory of solid and compare them with the free electron model.

(15/25)

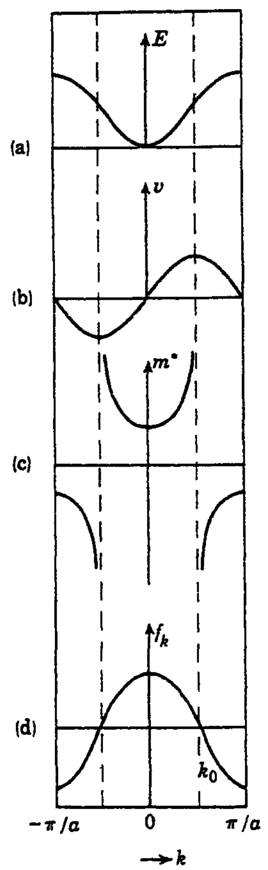

Fig. 1. Energy, velocity, effective mass and f_k as function of k. The dashed lines correspond to the inflection points in the $E(k)$ curve.

(b) From (a) discuss how the band theory of solid can explain why certain materials show a positive rather than a negative Hall coefficient.

(10/25)

4. (a) Some workers feel that there are only two types of materials, metals and semiconductors. Give a brief discussion on this statement.

(8/20)

(b) In an intrinsic semiconductor the effective mass of an electron is $0.07m_e$ and that of the hole is $0.4m_e$ where m_e is the rest mass of the electron. The mobility of electrons $\mu_e = 0.39\ m^2V^{-1}s^{-1}$ and holes $\mu_p = 0.19\ m^2V^{-1}s^{-1}$ and the energy gap $E_g = 0.7$ eV. Calculate the concentration of electrons and holes at 300 K and determine the conductivity of this material.

(12/20)

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