UNIVERSITI SAINS MALAYSIA

KSCP Semester Examination
Academic Session 2004/2005

Mei 2005

ZCT 317E/3 - Solid State Physics II
[Fizik Keadaan pepejal II]

Duration: 3 hours
[Masa : 3 jam]

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

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

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

*[**Arahan**: Jawab mana-mana **EMPAT** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

1. (a) The primitive translation vectors of a two dimensional (2-D) rectangular lattice are given by
[Vektor-vektor translasi primitif bagi suatu kekisi segi-empat dua dimensi (2-D) adalah diberi oleh]

$$\mathbf{a}_1 = a\hat{x} \quad \mathbf{a}_2 = 2a\hat{y}$$

(i) Determine the primitive translation vectors of the reciprocal lattice.
[Tentukan vektor translasi primitif bagi kekisi salingan].

(30/100)

(ii) Sketch the first Brillouin zone.
[Lakarkan zon Brillouin pertama].

(20/100)

(iii) Calculate the area of the first Brillouin zone.
[Hitungkan luas zone Brillouin pertama].

(10/100)

(b) What is the formula for the momentum of an electron in a solid in terms of its wave vector **k** ? Describe the conservation of momentum in a collision between an electron and a phonon.
*[Apakah formula bagi momentum suatu elektron dalam suatu pepejal dengan sebutan vektor gelombang-nya **k** ? Huraikan keabadian momentum dalam suatu pelanggaran di antara suatu elektron dengan suatu fonon].*

(40/100)

2. (a) Show that for free electron gas in three dimensions (3-D) containing N electrons, each of mass m in a volume V
[Tunjukkan bahawa bagi suatu gas elektron bebas dalam tiga dimensi (3-D) yang mempunyai N elektron berjisim m dalam isipadu V]

(i) The Fermi energy ε_F is given by
[Tenaga Fermi ε_F adalah diberi oleh]

$$\varepsilon_F = \frac{\hbar^2}{2m}\left(\frac{3\pi^2 N}{V}\right)^{2/3}$$

(30/100)

(ii) The electron density of states $D(\varepsilon)$ is given by
[Ketumpatan keadaan elektron $D(\varepsilon)$ adalah diberi oleh]

$$D(\varepsilon) = \frac{V}{2\pi^2}\left(\frac{2m}{\hbar^2}\right)^{3/2}\varepsilon^{1/2}$$

(30/100)

(b) Compare briefly the Sommerfeld Theory and the Bloch Theory of an electron in a solid.
[Bandingkan secara ringkas perbezaan di antara Teori Sommerfeld dan Teori Bloch bagi suatu elektron dalam pepejal]

(40/100)

3. (a) Explain clearly the Meissner Effect in a superconductor. State and explain the equation which describes this effect. (You are not required to prove this equation).
[Jelaskan Kesan Meissner dalam suatu superkonduktor. Nyatakan dan jelaskan persamaan yang menghuraikan kesan ini. (Anda tidak perlu buktikan persamaan ini).]

(20/100)

(b) (i) Sketch graphs of the magnetization versus applied magnetic field for a superconductor to show the behaviour of Type I and Type II superconductors. Explain the meaning of applied critical magnetic field for Type I and Type II superconductors.
[Lakarkan rajah rajah bagi kemagnetan lawan medan magnetik dikenakan bagi suatu superkonduktor untuk menunjukkan kelakuan Superkonduktor Jenis I dan Superkonduktor Jenis II. Jelaskan makna medan magnetik genting bagi kedua-dua jenis superkonduktor.]

(40/100)

(ii) Why are Type II superconductors more useful for applications?
[Apa sebab-nya superkonduktor jenis II adalah lebih sesuai untuk aplikasi ?]

(10/100)

(c) The superconducting transition temperature of Lead, $_{82}Pb^{208}$ (atomic mass = 207.9766 u) is $T_c = 7.19$ K. Given that the value of $\alpha = 0.49$ for Pb in the equation for the Isotope Effect, calculate the superconducting transition temperature T_c for $_{82}Pb^{207}$ (atomic mass = 206.9759 u).
[Suhu peralihan bagi Plumbum, $_{82}Pb^{208}$ (atomic mass = 207.9766 u) adalah $T_c = 7.19$ K. Diberi nilai $\alpha = 0.49$ bagi Pb dalam persamaan Kesan Isotop, hitungkan suhu peralihan T_c bagi $_{82}Pb^{207}$ (atomic mass = 206.9759 u)].

(30/100)

4. (a) Explain briefly the microscopic origin of paramagnetism and diamagnetism in solids.
[Jelaskan secara ringkas keasalan mikroskopik bagi keparamagnetan dan kediamagnetan dalam pepejal.]

(20/100)

(b) A paramagnetic substance contains ions with L = 0, S = ½ and J = ½. Show that when an external magnetic field B is applied, the magnetization M is given by
[Suatu bahan paramagnet mempunyai ion-ion dengan L = 0, S = ½ dan J = ½. Tunjukkan bahawa apabila suatu medan magnetik luar dikenakan, kemagnetan M adalah diberi oleh]

$$M = N\mu \tanh(\frac{\mu B}{k_B T})$$

where *[dimana]*

N = number of ions per unit volume *[nombor ion se unit isipadu]*
μ = magnetic moment of each ion *[momen magnetik bagi setiap ion]*
T = absolute temperature of substance *[suhu mutlak bagi bahan]*

(40/100)

(c) (i) Derive the formula for M at high temperatures.
[Terbitkan formula bagi M pada suhu tinggi]

(20/100)

(ii) Derive the paramagnetic susceptibility at high temperatures.
[Terbitkan kerentanan paramagnetik pada suhu tinggi]

(20/100)

5. (a) Describe the main differences between diamagnetic, paramagnetic and ferromagnetic behaviour of solids.
[Huraikan perbezaan utama diantara sifat diamagnetik, sifat paramagnetik dan sifat ferromagnetik bagi pepejal]

(20/100)

(b) Discuss the mean field theory of ferromagnets and show how the behaviour of the magnetization in zero magnetic field can be derived.
[Bincangkan teori medan min bagi ferromagnet dan tunjukkan bagaimana kelakuan kemagnetan dalam medan magnetik sifar boleh diterbitkan]

(50/100)

(b) Show that the magnetic susceptibility χ for temperatures $T > T_c$ is given by
[Tunjukkan bahawa kerentanan magnetik χ bagi suhu $T > T_c$ adalah diberi oleh]

$$\chi = \frac{C}{T - T_c}$$

where C is the Curie constant.
[dimana C adalah pemalar Curie]

(30/100)

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