UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2003/2004

February/March 2004

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 all **FIVE (5)** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

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

1. (a) (i) What is the concept of the Lattice Mode of Vibration?
[(i) Nyatakan konsep Mod Getaran bagi kekisi.]

(2/20)

(ii) The unit cell side of sodium chloride crystal is 5.6123 Å and Young's modulus in a [100] direction is 5×10^{10} Nm^{-2}. Calculate the wavelength at which electromagnetic radiation is strongly reflected by sodium chloride crystal, explaining the assumptions made by you. (Atomic Weight Na = 23, Cl = 37).

[(ii) Sisi unit sel hablur natrium klorida adalah 5.6123 Å dan Modulus Young dalam arah [100] adalah 5×10^{10} Nm^{-2}. Kira panjang gelombang di mana pancaran elektromagnet dibalikkan dengan kuat oleh hablur natrium klorida, berserta penjelasan mengenai anggapan-anggapan yang anda buat. (Berat atom Na = 23, Cl = 37).]

(8/20)

(b) (i) What are the concepts of Photons and Phonons?
[(i) Apakah konsep Foton dan Fonon?]

(4/20)

(ii) Calculate the maximum phonon frequency generated by scattering of visible light of wavelength λ = 5500 Å. Given that velocity of sound in medium is 5×10^5 cm/sec, and refractive index is 1.5.

[(ii) Kira frekuensi fonon maksimum yang dihasilkan oleh serakan cahaya nampak dengan panjang gelombang λ = 5500 Å. Diberi halaju bunyi dalam medium adalah 5×10^5 cm/s, dan indeks biasan adalah 1.5.]

(6/20)

2. (a) (i) Explain the meaning of magneto-resistance.
(i) Jelaskan maksud rintangan-magneto.

(2/20)

(ii) Show that if mean free path is independent of the velocity, the electrical conductivity of Maxwell-Boltzmann free electron gas may be expressed by the relation

[(ii) Tunjukkan jika lintasan bebas purata tidak bergantung kepada halaju, kekonduksian elektrik bagi gas elektron bebas Maxwell-Boltzmann dapat dinyatakan oleh kaitan]

$$\sigma = \frac{4}{3} \cdot \frac{n e^2 \lambda}{\sqrt{2\lambda m k T}}$$

(5/20)

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(b) (i) Explain what are dielectric materials. Describe a method to measure the dielectric constant of such materials.

[(i) Jelaskan apakah bahan dielektrik. Perihalkan kaedah bagi mengukur pemalar dielektrik bahan tersebut.]

(3/20)

(ii) Derive Clausius-Mosotti relation for insulators for a system of N_i atoms with ionic polarizability α_i, N_e atoms with electronic polarizability α_e and N_d with dipolar polarizability α_d :

[(ii) Terbitkan hubungan Clausius-Mosotti bagi penebat untuk suatu sistem terdiri dari atom-atom N_i dengan keterkutuban ion α_i, atom-atom N_e dengan keterkutuban elektron α_e dan atom-atom N_d dengan keterkutuban α_d :]

$\frac{\varepsilon-1}{\varepsilon+2}=\frac{4\pi}{3}(N_i\alpha_i+N_e\alpha_e+N_d\alpha_d)$ in a highly polarizable system.

(7/20)

(iii) A metal has a conductivity of 4×10^7 mho/m. Assuming that the true charge carriers are free electrons and they are $2 \times 10^{28}/m^3$, calculate the relaxation time.
(Mass of the electron $m = 9.1 \times 10^{-31}$ kg, charge of the electron $e = 1.6 \times 10^{-19}$ Coulombs).

(iii) Suatu logam mempunyai kekonduksian 4×10^7 mho/m. Dengan menganggap pembawa cas sebenar adalah elektron bebas dengan kepekatan $2 \times 10^{28}/m^3$, kira masa relaksasi.
(Jisim elektron $m = 9.1 \times 10^{-31}$ kg, cas elektron $e = 1.6 \times 10^{-19}$ Coulombs).

(3/20)

3. (a) (i) Explain Coulomb's Law in a homogeneous dielectric medium.

[(i) Jelaskan Hukum Coulomb dalam suatu medium dielektrik seragam.]

(2/20)

(ii) A parallel plate capacitor has an area 20 cm^2 and separation between the plates is 0.2 mm. The space between the plates is filled with a dielectric having the real part of the dielectric constant, $\varepsilon_r = 2.5$ when subjected to a 2 Volt alternating voltage of 1 MHz. The loss tangent at this frequency is 4×10^{-4}. Find the element of an equivalent (i) parallel R-C circuit, and (ii) series R-C circuit ($\varepsilon_o = 8.85 \times 10^{-12}$ F/m).

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[(ii) Suatu kapasitor plat selari mempunyai luas 20 cm^2 dan pemisahan antara plat 0.2 mm. Ruang diantara plat dipenuhi dengan dielektrik yang mempunyai pemalar dielektrik bahagian sahih ε_r = 2.5 apabila voltan ulangalik 2 Volt dan frekuensi 1 MHz dikenakan. Kehilangan tangent pada frekuensi ini adalah 4×10^{-4}. Tentukan elemen setara bagi (i) litar R-C selari dan (ii) litar R-C siri ($\varepsilon_o = 8.85 \times 10^{-12}$ F/m).]

(10/20)

(b) (i) Write down the classification of magnetic materials on the basis of magnetic properties of substances.

[(i) Tuliskan pengkelasan bahan-bahan magnet berdasarkan sifat-sifat magnet bahan.]

(4/20)

(ii) Describe any four applications of ferromagnetic materials.

[(ii) Perihalkan sebarang empat penggunaan bagi bahan ferromagnet.]

(4/20)

4. (a) What is fermi energy or Fermi level?

[(a) Apakah tenaga Fermi atau paras Fermi?]

(2/20)

(b) Explain the motion of electrons in a simple one-dimensional periodic potential based on Kronig-Penney model.

[(b) Jelaskan pergerakan elektron dalam keupayaan berkala mudah satu-dimensi berasaskan model Kronig-Penney.]

(18/20)

5. (a) Explain London theory of superconductivity.

[(a) Jelaskan teori London bagi superkonduktiviti.]

(5/20)

(b) The critical temperature T_c for mercury with isotopic mass 199.5 is 4.185 K. Calculate its critical temperature when its isotropic mass changes to 203.4.

[(b) Suhu genting T_c bagi raksa dengan jisim isotop 199.5 adalah 4.185 K. Kira suhu gentingnya bila jisim isotop bertukar kepada 203.4.]

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(c) Prove that superconductors are perfect diamagnet.

[(c) Buktikan superkonduktor adalah diamagnet sempurna.]

(5/20)

(d) Calculate the critical current which flow through a long thin superconducting wire of aluminium of diameter 10^{-3} metre. The critical magnetic field for aluminium is 7.9×10^3 amp/metre.

[(d) Kira arus genting yang mengalir melalui dawai superkonduktor aluminium yang panjang dan nipis bergarispusat 10^{-3} meter. Medan magnet genting bagi aluminium adalah 7.9×10^3 amp/meter.]

(5/20)

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