UNIVERSITI SAINS MALAYSIA

Final Examination
2016/2017 Academic Session

May/June 2017

JIF 417 – Solid State Physics
[Ilmu Fizik Keadaan Pepejal]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **SEVEN** printed pages before you begin the examination.

Answer **ALL** questions. You may answer **either** in Bahasa Malaysia or in English.

Read the instructions carefully before answering.

In the event of any discrepancies in the exam questions, the English version shall be used.

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

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

Baca arahan dengan teliti sebelum anda menjawab soalan.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Answer **ALL** questions.
*Jawab **SEMUA** soalan.*

1. (a) Briefly define or explain the following terms:

(i) Bravais Lattice

(ii) Primitive Unit Cell

(iii) Wigner-Seitz Cell

(iv) Packing Fraction

(v) Coordinate Number

(50 marks)

(b) You are given a small bar of an unknown metal. You find the density of the metal to be 11.5 g/cm^3. An X-ray diffraction experiment measures the edge of the face-centered cubic unit cell as 4.06 x 10^{-10} m. Find the gram-atomic weight of this metal and identify it.

(50 marks)

(a) Secara ringkas takrifkan atau jelaskan perkara berikut:

(i) Kekisi Bravais

(ii) Unit Sel Primitif

(iii) Sel Wigner-Seitz

(iv) Pecahan Padatan

(v) Nombor Koordinat

(50 markah)

(b) Anda diberi sebatang kecil logam yang tidak diketahui. Anda dapati ketumpatan logam tersebut adalah 11.5 g/cm^3. Eksperimen belauan sinar-X menunjukkan sisi unit sel kiub berpusat muka adalah 4.06 x 10^{-10} m. Dapatkan berat gram-atom bagi logam berkenaan dan kenal pastikannya.

(50 markah)

2. (a) Describe a Brillouin zone.

Jelaskan zon Brillouin.

(40 marks/*markah*)

(b) Iron (Fe) at room temprature has a bcc structure with a lattice parameter a = 2.87 Å. Find the maximum k value of the first Brillouin zone in the <110> direction for iron.

Besi (Fe) pada suhu bilik mempunyai struktur bcc dengan parameter kekisi a=2.87 Å. Dapatkan nilai k maksimum zon Brilloun pertama pada arah <110> untuk besi.

(60 marks/*markah*)

3. (a) Explain the Debye model and how it differs from the Einstein model.

Terangkan model Debye dan bagaimana ia berbeza dengan model Einstein.

(40 marks/*markah*)

(b) Estimate the Debye temprature for Lead (Pb). The sound velocity in lead, v_s = 1000 m/s and lattice parameter a = 4.95×10^{-8}cm.

Anggarkan suhu Debye untuk plumbum (Pb). Halaju bunyi dalam plumbum, v_s = 1000 m/s dan parameter kekisi a = 4.95×10^{-8}cm.

(60 marks/*markah*)

4. (a) Find the expressions for the density of states g(ε) for electrons in one, two, and three dimensions. Verify that g(ε) becomes constant in the two-dimensional case. Use the free electron model.

Dapatkan ungkapan ketumpatan keadaan g(ε) untuk elektron dalam satu, dua, dan tiga dimensi. Sahkan bahawa g(ε) menjadi malar dalam kes dua dimensi. Gunakan model elektron bebas.

(20 marks/*markah*)

(b) Explain the term "Fermi energy".
Terangkan maksud "Tenaga Fermi".

(20 marks/*markah*)

(c) Find the corresponding expressions for the Fermi energy, ε_F in 2D and 3D.

Dapatkan ungkapan sepadan untuk tenaga Fermi, ε_F dalam 2D dan 3D.

(20 marks/*markah*)

(d) The electronic specific heat is linear with temperature, $C_{v,el} = \gamma T$. Use the Lorenz number, $L=\pi^2 k_B^2/3e^2$ and Weiedemann-Franz law to express γ in term of ε_F. Describe the usage of these relations.
Haba tentu elektronik adalah linear dengan suhu, $C_{v,el} = \gamma T$. Gunakan nombor Lorenz, $L=\gamma^2 k_B^2/3e^2$ dan hukum Weiedemann-Franz untuk ungkapan γ dalam sebutan γ_F. Jelaskan kegunaan hubungan berkenaan.

(40 marks/*markah*)

5. (a) Sketch the band structure of a pure semiconductor.
Lakarkan struktur jalur semikonduktor tulen.

(30 marks/*markah*)

(b) Describe what happens to the band structure if impurities, such as donors or acceptors, of very low concentration are added to the specimen.
Jelaskan apa yang berlaku kepada struktur jalur jika bendasing seperti penderma atau penerima, dengan kepekatan sangat rendah ditambah kepada spesimen.

(30 marks/*markah*)

(c) Briefly describe the following concepts of superconductivity: superconducting gap, Cooper pairs, tunneling, isotope effect, condensation energy and vortices. *Jelaskan secara ringkas konsep superkonduktor berikut: celah pengkonduk super, pasangan kuprum, penerowongan, kesan isotop, tenaga kondensasi, vortis.*

(40 marks/*markah*)

IUPAC Periodic Table of the Elements

1																	18
1 H hydrogen [1.007, 1.009]	2		Key: atomic number **Symbol** name standard atomic weight									13	14	15	16	17	2 He helium 4.003
3 Li lithium [6.938, 6.997]	4 Be beryllium 9.012											5 B boron [10.80, 10.83]	6 C carbon [12.00, 12.02]	7 N nitrogen [14.00, 14.01]	8 O oxygen [15.99, 16.00]	9 F fluorine 19.00	10 Ne neon 20.18
11 Na sodium 22.99	12 Mg magnesium [24.30, 24.31]	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 26.98	14 Si silicon [28.08, 28.09]	15 P phosphorus 30.97	16 S sulfur [32.05, 32.08]	17 Cl chlorine [35.44, 35.46]	18 Ar argon 39.95
19 K potassium 39.10	20 Ca calcium 40.08	21 Sc scandium 44.96	22 Ti titanium 47.87	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.38(2)	31 Ga gallium 69.72	32 Ge germanium 72.63	33 As arsenic 74.92	34 Se selenium 78.97	35 Br bromine [79.90, 79.91]	36 Kr krypton 83.80
37 Rb rubidium 85.47	38 Sr strontium 87.62	39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.95	43 Tc technetium	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57-71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium [204.3, 204.4]	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89-103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Uut ununtrium	114 Fl flerovium	115 Uup ununpentium	116 Lv livermorium	117 Uus ununseptium	118 Uuo ununoctium

57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
89 Ac actinium	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

For notes and updates to this table, see www.iupac.org. This version is dated 8 January 2016.

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