UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

ZAE 282/3 – Material Sciences
[Sains Bahan]

Duration: 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **SEVEN** printed pages before you begin the examination.
*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

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

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

...2/-

1. (a) Show for the *[Tunjukkan bagi]*

(i) body – centered cubic crystal structure that the unit cell edge length $\boldsymbol{a}$ and the atomic radius $\boldsymbol{R}$ are related through $\boldsymbol{a} = 4R / \sqrt{3}$.
[Sel unit berpusat jasad bahawa panjang sisi $\boldsymbol{a}$ *dan jejari* $\boldsymbol{R}$ *dihubungjan melalui* $\boldsymbol{a} = 4R / \sqrt{3}$.*]*

(ii) atomic packing factor for BCC is 0.68.
[faktor pemadatan atom bagi BCC ialah 0.68.]

(iii) atomic packing factor for FCC is *0.74.*
[faktor pemadatan atom bagi FCC ialah 0.74.]

(30/100)

(b) The density of thorium, which has the FCC structure and one atom per lattice point is 11.72 g/cm^3. The atomic weight of thorium is 232 g/mol. Calculate :
[Ketumpatan thorium yang memiliki struktur FCC dan satu atom per titik kekisi ialah 11.72 g/cm^3. Berat atom thorium ialah 232 g/mol. Hintungkan:]

(i) the lattice parameter
[parameter kekisi]

(ii) the atomic radius of thorium
[jejari atom thorium]

(30/100)

(c) Gallium has an orthorhombic structure, with $a_o = 0.45258$ nm, $b_o = 0.45186$ nm, and $c_o = 0.76570$ nm. The atomic radius is 0.1218 nm. The density is 5.904 g/cm^3 and the atomic weight is 69.72 g/mol. Determine:
[Gallium mempunyai struktur orthorhombik dengan $a_o = 0.45258$ *nm,* $b_o = 0.45186$ *nm, and* $c_o = 0.76570$ *nm. Jejari atom ialah 0.1218 nm. Ketumpatannya ialah 5.904 g/cm^3 dan berat atom ialah 69.72 g/mol. Tentukan:]*

(i) the number of atoms in each unit cell
[bilangan atom di dalam satu sel-unit]

(ii) the packing factor for the unit cell
[faktor pemadatan di dalam sel-unit]

(40/100)

...3/-

2. (a) Determine the Miller indices of the plane that passes through three points having the following coordinates:
[Tentukan indeks Miller bagi satah yang melalui tiga titik dengan koordinat berikut:]

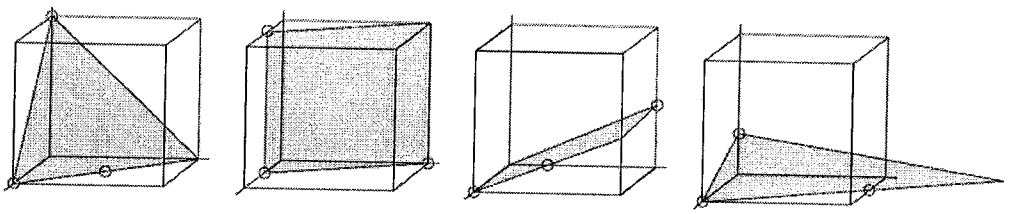
(i) 0,0,1; 1,0,0; and 1/2,1/2,0

(ii) 1/2,0,1; 1/2,0,0; and 0,1,0

(iii) 1,0,0; 0,1,1/2; and 1,1/2,1/4

(iv) 1,0,0; 0,0,1/4; and 1/2,1,0

(30/100)



(a) (b) (c) (d)

(b) Derive an equation relating x-ray wavelength, interatomic spacing, and angle of diffraction for constructive interference and hence show that d_{hkl} is a function of Miller indices (h,k,l).
[Terbitkan satu persamaan yang mengkaitkan jarak gelombang Sinar-x, jarak antara–atom, dan sudut pembelauan bagi interferens membina dan tunjukan d_{hkl} adalah satu fungsi indeks Miller (h,k,l).]

(30/100)

(c) Explain the following:
[Terangkan]

(i) Any three types of defects in crystals
[3 jenis kecacatan hablur]

(ii) Fick's first law – diffusion flux for steady state diffusion
[Hukum pertama Fick–fluks resapan bagi resapan keadaan mantap]

(40/100)

3. (a) The following data (table 1) were collected from a 20 mm diameter test specimen of a ductile cast iron ($l_o = 40.00$ mm):
[Data berikut (jadual 1) dikutip dari satu spesimen besi tuang mulur ujian berdiameter 20mm ($l_o = 40.00$ mm):]

$$\sigma = F/(\pi/4)(20\text{ mm})^2 = F/314.2$$

$$\varepsilon = (l - 40)/40$$

Load *[Beban]* (N)	Gage Length *[Panjang Tolak]* (mm)	Stress *[Tegasan]* (MPa)	Strain *[Terikan]* (mm/mm)
0	40.0000	0	0.0
25,000	40.0185	79.6	0.00046
50,000	40.0370	159.2	0.000925
75,000	40.0555	238.7	0.001388
90,000	40.20	286.5	0.005
105,000	40.60	334.2	0.015
120,000	41.56	382.0	0.039
131,000	44.00 (max load)	417.0	0.010
125,000	47.52 (fracture)	397.9	0.188

Table 1 *[Jadual 1]*

After fracture, the gage length was measured as 47.42 mm and the diameter as 18.35 mm. Using the data, calculate:
[Selepas patah, panjang tolak yang di ukur ialah 47.42mm dan diameternya ialah 18.35mm. Menggunakan data, hintung :]

(i) Tensile strength
[Kekuatan tegangan]

(ii) Modulus of elasticity
[Modulus kekenyalan]

(iii) % Elongation
[% Pemanjangan]

(iv) % Reduction in area
[% Pengurang luas]

(v) Engineering stress at fracture
[Ketegasan kejuruteraan semasa patah]

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(vi) True stress at fracture
[Ketegasan sebenar semasa patah]

(vii) Modulus of resilience
[Modulus kebingkasan]

(50/100)

(b) Describe the following Strengthening Mechanisms in metals:
[Perihalkan Mekanisma Penguatan di dalam logam berikut :]

(i) Grain Size reduction
[Pengurangan saiz butiran]

(ii) Solid-solution strengthening
[Penguatan larutan pepejal]

(iii) Strain hardening
[Pengerasan keterikan]

Also explain the characteristics of dislocations that are involved in each of the strengthening techniques.
[Juga terangkan ciri-ciri perkehelan yang terlibat di dalam setiap teknik penguatan.]

(50/100)

4. (a) Explain the following terms with relevant theory:
[Terangkan istilah-istilah berikut mengikut teori yang releven:]

(i) Phase Equilibrium & Phase diagrams
[Keseimbangan Fasa dan Rajah Fasa]

(ii) Eutectic Systems
[Sistem-sistem Eutektik]

(iii) Iron –Carbon (Fe –C) phase diagram
[Rajah fasa Ferum – karbon (Fe – C)]

(60/100)

(b) Silicon carbide (SiC) has a specific gravity of 3.1 g/cm^3. A sintered SiC part is produced, occupying a volume of 500 cm^3 and weighing 1200 g. After soaking in water, the part weighs 1250 g. Calculate
[Silikon karbida (SiC) mempunyai graviti tertentu 3.1 g/cm^3. Satu bahagian tersinter dihasilkan yang mengambil isipadu 500cm^3 dan timbangan 1200 g. Selepas direndam di dalam air, bahagian itu menimbang 1250 g. Hitung]

(i) bulk density
[ketumpatan pukal]

(ii) true porosity
[keliangan sebenar]

(iii) volume fraction of the total porosity that consists of closed pores.
[pecahan isipadu dari jumlah keliangan yang terdiri daripada liang tertutup.]

(40/100)

5. (a) Steel is coated with a thin layer of ceramic to help protect against corrosion. What do you expect to happen to the coating when the temperature of the steel is increased significantly? Explain.
[Keluli di salut dengan satu lapisan nipis seramik untuk membantu melindungi daripada kakisan. Apakah yang anda jangka akan berlaku kepada salutan itu apabila suhu keluli ditingkatkan dengan lebih tinggi. Terangkan.]

(20/100)

(b) A 1-m- square steel plate is coated on both sides with a 0.005cm-thick layer of zinc. A current density of 0.02 A/cm^2 is applied to the plate in an aqueous solution. Assuming that the zinc corrodes uniformly, determine the length of time required before the steel is exposed.
[Satu plat keluli segi-empat sama 1-m disalut pada kedua-dua permukaan dengan lapisan zink setebal 0.005cm. Satu ketumpatan arus 0.02 A/cm^2 dikenakan kepada plat di dalam larutan air. Dengan mengandaikan zink mengkakis secara seragam, tentukan panjang masa yang diperlukan untuk mendedahkan keluli.]

(40/100)

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(c) An alumina insulator for an electrical device is also used as a heat sink. Temperature rise of 10° C is observed during use in this alumina insulator (1 cm × 1 cm × 0.02 cm). Determine the thickness of a high-density polyethylene insulator that would be needed to provide the same performance as a heat sink. The density of alumina is 3.96 g/cm^3.
[Satu penebat alumina untuk alatan elektrik turut digunakan sebagai penggelam haba. Peningkatan suhu sebanyak 10 °C telah diperhatikan semasa penggunaan alumina ini sebagai penebat (1 cm × 1 cm × 0.02 cm). Tentukan ketebalan satu penebat polyethylene berketumpatan tinggi yang perlu diperlukan untuk menghasilkan prestasi yang sama sebagai pengelam haba. Ketumpatan alumina ialah 3.96 g/cm^3.]

(40/100)

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