UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2012/2013

January 2013

EBB 202/3 – Crystallography & bonding In Solids
[Kristalografi & Ikatan Dalam Pepejal]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains <u>ELEVEN</u> printed pages and <u>TWO</u> pages APPENDIX before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi <u>SEBELAS</u> muka surat yang bercetak dan <u>DUA</u> muka surat LAMPIRAN sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions. ONE question from PART A, THREE questions from PART B and THREE questions from PART C.
[Kertas soalan ini mengandungi TUJUH soalan. SATU soalan dari BAHAGIAN A, TIGA soalan dari BAHAGIAN B dan TIGA soalan dari BAHAGIAN C.]

Instruction: Answer FIVE questions. Answer **ALL** questions from PART A and **TWO** questions from PART B and **TWO** questions from PART C. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab LIMA soalan. Jawab **SEMUA** soalan dari BAHAGIAN A dan **DUA** soalan dari BAHAGIAN B dan **DUA** soalan dari BAHAGIAN C. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

PART A / *BAHAGIAN A*

1. [a] With the help of appropriate diagrams, explain what are the differences between single crystal, polycrystalline and amorphous solid.

   Dengan bantuan gambarajah yang bersesuaian, terangkan perbezaan antara hablur tunggal, polihablur, dan amorfus.

   (30 marks/*markah*)

   [b] Define the following terms: symmetry of crystals, symmetry elements and symmetry operation?

   Apakah definisi terma-terma berikut: simetri hablur, simetri unsur-unsur dan operasi simetri?

   (20 marks/*markah*)

   [c] (i) What are the two (2) differences and similarities between X-ray diffraction (XRD), X-ray fluorescence (XRF) and energy-dispersive X-ray spectroscopy (EDX)?

   Apakah dua (2) perbezaan dan persamaan antara pembelauan sinar-X (XRD), pendaflour sinar-X (XRF) dan serakan tenaga spektroskopi sinar-X (EDX)?

   (20 marks/*markah*)

(ii)   Indicate if it is possible to characterize zinc oxide (ZnO) using X-ray diffraction (XRD) and X-ray fluorescence (XRF)?

Adakah mungkin untuk mencirikan zink oksida (ZnO) menggunakan pembelauan sinar-X (XRD) dan pendarfluor sinar-X (XRF)?

(20 marks/*markah*)

(iii)   Explain the reason for broadening of the XRD peaks.

Terangkan sebab pengembangan puncak XRD.

(10 marks/*markah*)

PART B / *BAHAGIAN B*

2. Materials properties are dependent on chemical bonding.

   Sifat bahan adalah bergantung kepada ikatan kimia.

   [a] With the help of appropriate diagrams, explain three (3) types of chemical bonding in solid.

   Dengan bantuan gambarajah yang bersesuaian, terangkan tiga (3) jenis ikatan kimia dalam pepejal.

   (45 marks/*markah*)

   [b] State the importance of chemical bonding in solids.

   Nyatakan kepentingan ikatan kimia dalam pepejal.

   (20 marks/*markah*)

   [c] You are given two types of metal; titanium (Ti) and copper (Cu). Explain why properties of both metals are being different. Given that atomic number of Ti = 22 and Cu = 29.

   Anda diberikan dua jenis logam; titanium (Ti) dan kuprum (Cu). Terangkan kenapa sifat-sifat kedua-dua logam tersebut berbeza. Diberikan nombor atom Ti = 22 dan Cu = 29.

   (35 marks/*markah*)

3. [a] There are 14 Bravais lattices. Draw and label properly the following:

    (i) All three dimensional Bravais lattices for tetragonal.

    (ii) All three dimensional Bravais lattices for monoclinic.

    Terdapat 14 kekisi Bravais. Lakarkan dan labelkan yang berikut:

    (i) Kesemua tiga dimensi kekisi Bravais untuk tetragonal.

    (ii) Kesemua tiga dimensi kekisi Bravais untuk monoklinik.

    (30 marks/*markah*)

    [b] In three dimensions there are additional symmetry elements that need to be considered. They are point and translational symmetry elements. Briefly explain appropriate applications of both point symmetry and translational symmetry elements.

    Dalam tiga dimensi terdapat tambahan unsur-unsur simetri yang perlu diambilkira, iaitu unsur-unsur simetri titik dan simetri peralihan. Terangkan dengan ringkas kegunaan unsur-unsur simetri titik dan simetri peralihan yang bersesuaian.

    (20 marks/*markah*)

    [c] Appendix 1 show four crystals: $CuSO_4.3H_2O$, $MgSO_4.7H_2O$, $FeSO_4.7H_2O$ and $CaCO_3$. Identify the symmetry elements that each of the crystals have and suggest the point group symmetry that these crystals could belong to. **Please draw on Appendix 1 and attach with your answer sheets**.

    *Lampiran 1 menunjukkan empat hablur; $CuSO_4.3H_2O$, $MgSO_4.7H_2O$, $FeSO_4.7H_2O$ dan $CaCO_3$. Kenalpasti unsur-unsur simetri setiap hablur tersebut dan cadangkan kumpulan simetri titik manakah hablur-hablur ini tergolong. **Sila lukis di atas Lampiran 1 dan sertakan bersama kertas jawapan anda.**

    (50 marks/*markah*)

4.   [a]   What is a stereographic projection?   Briefly explain the importance of stereographic projection.

Apakah unjuran stereografik?   Terangkan dengan ringkas kepentingan unjuran stereografik.

(30 marks/*markah*)

[b]   Sketch the full image for the stereographic projection in Appendix 2. **Please attach Appendix 2 with your answer sheets**.

*Lakarkan gambar penuh untuk unjuran stereografik dalam Lampiran 2. **Lampirkan Lampiran 2 bersama kertas jawapan anda**.*

(40 marks/*markah*)

[c]   Barium titanate, $BaTiO_3$ is a known ferroelectric material.   With the help of appropriate diagrams, explain properties of $BaTiO_3$ with varying the temperature in relation with crystal structure.

Barium titanat, $BaTiO_3$ merupakan bahan ferroelektrik yang terkenal.   Dengan bantuan gambarajah yang bersesuaian, terangkan sifat-sifat $BaTiO_3$ dengan perubahan suhu dan perkaitan dengan struktur hablur.

(30 marks/*markah*)

PART C / *BAHAGIAN C*

5.　　[a]　Determine the Miller indices for the planes shown in the following unit cell (Figure 1):

Tentukan indeks Miller untuk satah-satah yang ditunjukkan dalam sel unit berikut (Rajah 1):
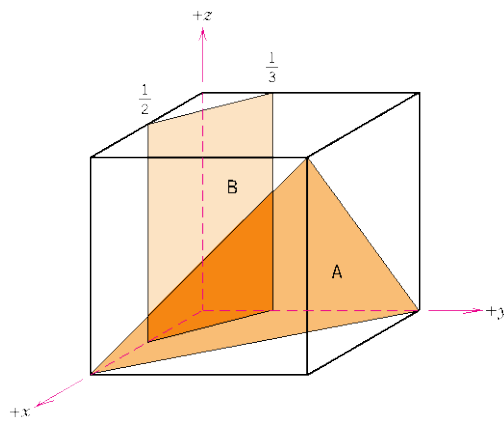

Figure 1: Unit Cell

Rajah 1: Sel Unit

(30 marks/*markah*)

　　　　[b]　Sketch the hexagonal crystal planes whose Miller-Bravais indices for (-1100).

Lukiskan satah-satah kristal heksagon yang bagi indeks Miller-Bravais untuk (-1100).

(30 marks/*markah*)

[c]   Determine the expected diffraction angle for the first-order reflection from the (310) set of planes for BCC chromium when monochromatic radiation of wavelength 0.0711 nm is used. Given R = 0.1249 nm and $a = \dfrac{4R}{\sqrt{3}}$.

Tentukan jangkaan sudut pembelauan untuk pantulan tertib-pertama dari set satah-satah (310) bagi kromium BCC menggunakan sinaran monokromatik panjang gelombang 0.0711 nm digunakan. Diberikan R = 0,1249 nm dan $a = \dfrac{4R}{\sqrt{3}}$.

(40 marks/*markah*)

6.   [a]   In crystallography study, what can be obtained from Moseley's Law?

Dalam kajian kristalografi, apa yang boleh didapati daripada Hukum Moseley?

(10 marks/*markah*)

[b]   Before you conduct XRD test, you discover that Mr Zaini Saari has changed the target/anode. To determine the chemical identity of the new target, you operate the XRD and find out the wavelength (λ) of the K_α peak to be 2.75 Å. What element of this target?

Sebelum anda menjalankan ujian XRD, anda mendapati bahawa Encik Zaini Saari telah mengubah sasaran/anod. Untuk menentukan identiti kimia sasaran baru, anda operasikan XRD dan mencari gelombang (λ) puncak K_α untuk menjadi 2.75 Å. Apakah unsur sasaran ini?

(30 marks/*markah*)

[c]   Identify the element giving rise to K_α with λ = 2.51 x 10^{-10} m.

Kenalpasti elemen yang memberikan nilai K_α dengan λ = 2.51 x 10^{-10} m.

(30 marks/*markah*)

[d]   Calculate the wavelength of $\lambda_{k\alpha}$ for molybdenum (Mo). (Refer to Periodic Table).

Kira panjang gelombang $\lambda_{k\alpha}$ untuk molibdenum (Mo). (Rujuk jadual berkala).

(30 marks/*markah*)

7.   [a]   Generally when talking about polymeric materials, glass transition temperature (T_g) is always mentioned. Why?

Umumnya apabila bercakap mengenai bahan polimer, suhu peralihan kaca (T_g) sentiasa disebut. Mengapa?

(20 marks/*markah*)

[b]   Explain the concept of the degree of percentage of crystallinity. Support your answer with an appropriate sketch.

Terangkan konsep peratusan darjah penghabluran. Sokong jawapan anda dengan lakaran yang sesuai.

(30 marks/*markah*)

[c]   Figure 2 shows XRD pattern of a polymeric materials. Calculate the percentage of crystallinity in the sample.

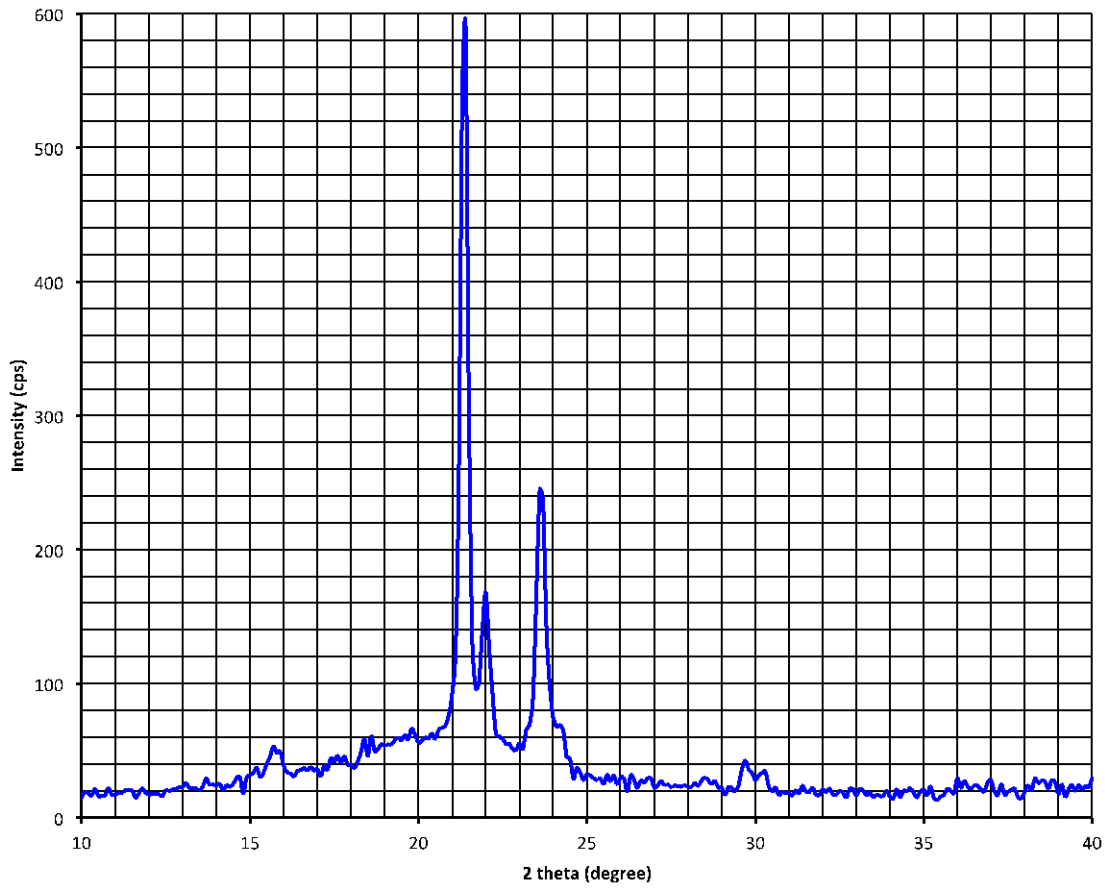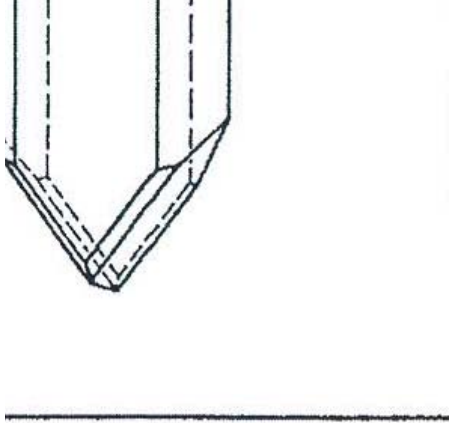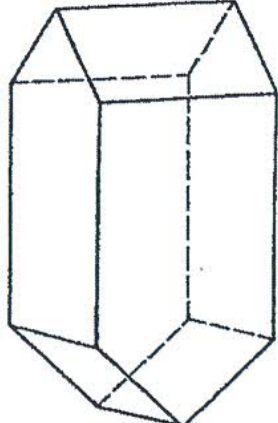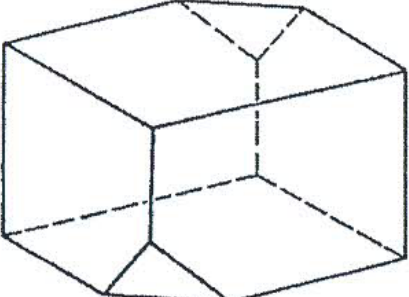*Rajah 2 menunjukkan corak XRD bahan polimer. Kira peratusan penghabluran sampel.*

Figure 2: XRD pattern of polymeric materials

Rajah 2: Corak XRD bahan polimer

(50 marks/*markah*)

Constant Value

Rydberg constant = 10,973,731.6 m^{-1}

Periodic Table

IA			Key		Metal												0

Key:
29 ← Atomic number
Cu ← Symbol
63.54 ← Atomic weight

Metal, Nonmetal, Intermediate

IA												IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0080	IIA																2 He 4.0026
3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
11 Na 22.990	12 Mg 24.312	IIIB	IVB	VB	VIB	VIIB	VIII		IB	IIB		13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.91	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	Rare earth series	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	Acti-nide series															

Rare earth series	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinide series	89 Ac (227)	90 Th 232.04	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lw (257)

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Appendix 1 / Lampiran 1

a) $CuSO_4.3H_2O$	b) $MgSO_4.7H_2O$
$_2O$	
c) $FeSO_4. 7H_2O$	d) $CaCO_3$

Appendix 2 (Please detach and include in your answer sheets)

Lampiran 2 (Sila ceraikan dan termasuk dalam kertas jawapan anda)

(i)

622

(ii)

3 m

(iii)

$\bar{3}\ \dfrac{2}{m}\ \dfrac{2}{m}$

(iv)

$\bar{4}\ m\ 2$

(v)

4 mm