UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2012/2013

January 2013

EBS 209/3 – Mineralogy
[Mineralogi]

Duration : 3 hours
[Masa : 3 jam]

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

This paper consists of SEVEN questions. TWO questions in PART A and FIVE questions in PART B.
[Kertas soalan ini mengandungi TUJUH soalan. DUA soalan di BAHAGIAN A dan LIMA soalan di BAHAGIAN B.]

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A and **THREE** questions from PART B. If a 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 **TIGA** soalan dari BAHAGIAN B. 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]   How is the crystal face of a crystal defined?   Miller Index is conventional notation or a way of identifying or indexing faces. How is the Miller Index for a crystal face determined?

For each of the following parameters of a crystal, calculate the Miller Indices.

(i) a : a : 3c   (ii) 2a : b: 5c   (iii) 3 /2a : 4/5b : 6/11c

Bagaimana muka-muka hablur pada suatu hablur boleh ditakrifkan? Indek Miller adalah notasi atau cara lazim yang digunapakai bagi mengenali atau memberi indeks muka-muka hablur. Bagaimana Miller Indeks bagi suatu muka hablur dilakukan?

Bagi setiap parameter-parameter berikut tentukan Indek Miller muka hablur itu.

(i) a : a : 3c   (ii) 2a : b: 5c   (iii) 3 /2a : 4/5b : 6/11c

[b]   Minerals have distinguishing physical properties that in most cases can be used to identify (identifying tool) the mineral. State and explain four (4) common physical properties of a mineral can be used for identification. Based on the selected typical physical properties, how can the following minerals be distinguished?

(i) Quartz   (ii) Galena   (iii) Calcite

Mineral dalam banyak keadaan mempunyai sifat-sifat fizikal unik yang dapat membantu kita mengecam identitinya (alat pengecaman). Nyata dan terangkan empat (4) sifat-sifat fizik berkenaan yang boleh digunakan dalam pengecaman mineral. Bersandarkan sifat-sifat fizikal lazim tersebut, bagaimana mineral-mineral berikut boleh dibezakan.

(i) Kuarza   (ii) Galena   (iii) Kalsit

[c]   For the following silicate and non-silicate minerals with specific chemical formulas, determine their respective class, group, sub-class and names based on the Brezilian classification system.

(i) MgO   (iii) Au   (v) SiO_2
(ii) $NaAlSi_3O_8$ (iv) $CaCO_3$ (vi) $Mg(OH)_2$

Untuk mineral silikat dan bukan silikat berikut dengan formula kimia tertentu, tentukan kelas, kumpulan, sub-kelas dan nama mineral berkenaan berasaskan kepada sistem pengelasan Brezilian?

(i) MgO   (iii)Au   (v) SiO_2
(ii) $NaAlSi_3O_8$ (iv) $CaCO_3$ (vi) $Mg(OH)_2$

(100 marks/*markah*)

2.   [a]   In mineral definition, "we say a mineral has a definite, but not necessarily fixed chemical composition", and this is often known as compositional variation in mineral. Please elaborate?

Graphically, show the variation of the two olivine groups (Fayalite and Forsterite) based on the chemical composition where the Mg^{+2} (60%) ions are replaced by the Fe^{+2} (40%) (plot).

Bagi definasi suatu mineral "kita mengatakan bahawa suatu mineral itu mempunyai komposisi kimia tertentu", akan tetapi tidak semestinya tetap. Ini sering dikenali sebagai variasi komposisi dalam mineral. Sila perjelaskan.

Secara grafik, bagaimana variasi komposisi bagi mineral kumpulan olivin (Fayalit dan Fosterit) yang boleh mepunyai darjah pengantian ion-ion Mg^{+2} (60%) dan Fe^{+2} (40%) berbeza boleh ditunjukkan (plot).

[b]   Determine the formula for the following copper-bearing mineral which has the following weight % composition.

$$Cu^{+2} = 63.3\% \quad S^{-2} = 25.5\%, \quad Fe^{+3} = 11.2\%$$

Kirakan formula bagi mineral tembaga yang mempunyai peratus berat komposisi seperti berikut.

$$Cu^{+2} = 63.3\% \quad S^{-2} = 25.5\%, \quad Fe^{+3} = 11.2\%$$

[c]   With a simple diagram, show how Bragg's Law for X-ray diffraction(XRD) is defined? For forsterite crystal of the following dimension, calculate 2θ for the (201) lattice spacing for Cuk_α ($\lambda = 1.5405$Å).

$$a = 4.75; b = 10.20; c = 5.98\text{Å}.$$

Dengan bantuan lakaran mudah tunjukkan bagaimana Hukum Bragg bagi Belauan sinar-X ditakrifkan. Untuk mineral fosterit dengan dimensi berikut, kirakan sudut 2θ bagi ruang satah kekisi (201) dengan Cuk_α ($\lambda = 1.5405$Å).

$$a = 4.75; b = 10.20; c = 5.98\text{Å}.$$

(100 marks/*markah*)

PART B / *BAHAGIAN B*

3.　　[a]　　What is axial ratio?

What are the axial ratio for the hexagonal quartz mineral and orthorhombic sulfur with the following unit cell dimensions as measured by x-ray crystallography, respectively.

(i)　　Quartz : $a_1 = a_2 = a_3 = 4.913$Å and $c = 5.405$Å

(ii)　　Sulfur crystal : $a = 10.47$Å, $b = 12.87$Å, $c = 24.39$Å
　　　　where Å stands for Angstroms = 10^{-10} meter

Apakah itu nisbah paksi?

Apakah nisbah paksi bagi mineral heksagonal kuarza dan sulfur ortorombik yang mempunyai dimensi unit sel berikut yang ditentukan secara kristalografi sinar-x, masing-masing.

(i)　　Kuarza = $a_1 = a_2 = a_3 = 4.913$Å dan $c = 5.405$Å

(ii)　　Hablur sulfur : $a = 10.47$Å, $b = 12.87$Å, $c = 24.39$Å,
　　　　yang mana Å mewakili unit Angstroms = 10^{-10} meter

PART B / *BAHAGIAN B*

[b]   Specific gravity or density of mineral can be defined in two ways, i.e. relation to mass of atom and number of atom in the unit cell, also relative to mass of water. Define.

Clinoenstatite (monoclinic) and Orthoenstatite (orthorhombic) are the two different polymorphs of pyroxene enstatite ($MgSiO_3$) mineral with the following cell edges respectively. Calculate the density of each polymorph?

Clinoenstatite : a = 9.605Å, b = 8.813Å, c = 5.166, β = 108.46º and Z = 8.
Orthoenstatite : a = 18.216Å, b = 8.813Å, c = 5.179, and Z = 16
Avogadro's number, N : $6.022 \times 10^{+23}$ (mole)
V = abc sin β (Monoclinic)

Graviti tentu atau ketumpatan mineral dapat ditakrif dalam dua pendakatan, iaitu perhubungan terhadap jisim dan bilangan atom dalam unit sel juga berat relativf kepada jisim air. Takrifkan.

Klinoenstatit (monoklinik) dan orthoenstatit (ortorombik) adalah dua polimof mineral pirosin enstatit berbeza dengan sisi-sisi unit sel seperti berikut. Kirakan ketumpatan bagi kedua-dua polimof berikut.

Clinoenstatite : a = 9.605Å, b = 8.813Å, c = 5.166, β = 108.46º and Z = 8.
Orthoenstatite : a = 18.216Å, b = 8.813Å, c = 5.179, and Z = 16
Nombor Avogadro, N : $6.022 \times 1^{+23}$ (atom)
V = abc sin β (Monoklinik)

(100 marks/*markah*)

4. [a] Magnetic minerals result from properties that are specific to a number of elements. State and describe main types of magnetism, and its relation to the presence of such elements, and unit.

Mineral magnetik berpunca daripada sifat sebilangan elemen/unsur tertentu. Nyata dan terangkan jenis-jenis kemagnetan, dan hubungkaitnya dengan kehadiran unsur-unsur tertentu itu, dan apakah unit pengukurannya?

[b] Define the following physical properties of minerals:-
   (i)   Colour
   (ii) Streak
   (iii) Luster

Takrifkan sifat-sifat fizikal bagi mineral berikut:-
   (i)   Warna
   (ii) Goresan
   (iii) Kilauan

[c] Given the following mineral formulas determine the valence (charge and number) of the element labeled "X" in each formula below. (P = +5)
   (i) $Mg_3X_2Si_3O_{12}$
   (ii) $X_3Al_2Si_6O_{18}$
   (iii) $Al_6XPO_4(OH)_8.2H_2O$
   (iv) $KAlX_3O_8$

*Bagi formula-formula kimia mineral-mineral berikut, tentukan valensi (cas dan nombor) bagi elemen yang dilabelkan "X"?*
   (i) $Mg_3X_2Si_3O_{12}$
   (ii) $X_3Al_2Si_6O_{18}$
   (iii) $Al_6XPO_4(OH)_8.2H_2O$
   (iv) $KAlX_3O_8$

(100 marks/*markah*)

5.   [a]   Using the general silicate formula, $X_mY_n(Z_pO_q)w_r$, match each appropriate element or element grouping and subscript in each mineral formula below with that of each letter or number in the general formula.

  i. $Be_3Al_2Si_6O_{18}$ iii. $CaAl_2Si_2O_7(OH)_2$
  ii. $Al_2Si_2O_5(OH)_4$ iv. $Mg_2Si_2O_6$
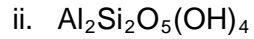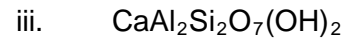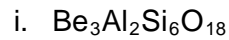
Menggunakan formula umum silikat $X_mY_n(Z_pO_q)w_r$, padankan setiap elemen atau kumpulan elemen dan subskrip dalam setiap mineral di bawah dengan setiap huruf atau nombor kedalam formula umum tersebut.

  iii. $Be_3Al_2Si_6O_{18}$ iii. $CaAl_2Si_2O_7(OH)_2$
  iv. $Al_2Si_2O_5(OH)_4$ iv. $Mg_2Si_2O_6$
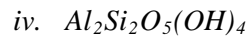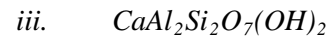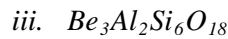
[b]   Identify the structure of the following silicate mineral class based on their polymerization of the silica tetrahedral.

Kenal pasti struktur bagi kelas mineral silikat berasaskan kepada polimerisasi ikatan tetrahedral silika berikut.

(a)   (b)   (c)
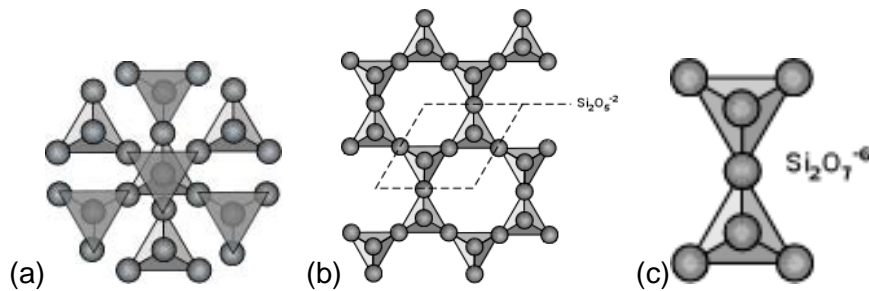
[c]   Generally mineral can be formed by any 4 processes.   State and briefly discuss such processes.

Secara umumnya mineral boleh terbentuk melalui proses-proses berikut. Sila nyata dan secara ringkas terangkan proses-proses berkenaan.

(100 marks/*markah*)

6. [a] Sketch and illustrate the possible polymerization structures (the silicate class) of the SiO_4 tetrahedra for the following silicate minerals.
   (i)   Olivin $(Mg,Fe)_2SiO_4$
   (ii) Feldspar $(NaAlSi_3O_8)$
   (iii) Quartz (SiO_2)

   Lakar dan ilustrasikan struktur polimerisasi (kelas silikat) tetrahedral SiO_4 yang munasabah bagi mineral-mineral silikat berikut.
   (i)   Olivin $(Mg,Fe)_2SiO_4$
   (ii) Feldspar $(NaAlSi_3O_8)$
   (iii) Quartz (SiO_2)

   [b] The common sulfide mineral pyrite (FeS_2) has a density of 5.02 g/cm^3 and a unit cell edge of 5.42Å. Calculate Z, the number of formula units per cell.

   Mineral sulfida pirit (FeS_2) lazimnya mempunyai ketumpatan 5.02 g/cm^3 dengan unit sisian 5.42 Å. Kirakan Z, nombor unit formula per sel.

   [c] Briefly define the following:-
   (i)   Crystal form
   (ii) General form
   (iii) Closed form

   Secara ringkas takrifkan perkara-perkara berikut:-
   (i)   Bentuk hablur
   (ii) Bentuk umum
   (iii) Bentuk tertutup

   (100 marks/*markah*)

7.   [a]   Generally mineral are classified on their chemistry, particularly on the anionic elements or polyanionic group of elements that occur in the mineral known as Berzelian classification system.   State at least five (5) different class of mineral and their respective Anion and Anion group and example of minerals for each class?

Mineral umumnya dikelaskan mengikut kimianya, terutama berasaskan unsur-unsur anion atau kumpulan polianion yang membentuk mineral itu yang dikenali sebagai sistem pengelasan Berzelian. Nyatakan sekurang-kurangnya lima (5) kelas mineral dengan anion atau kumpulan anionnya berserta contoh-contoh mineral bagi setiap kelas itu.

[b]   Determine the chemical formula for the mineral with the following composition.

Element oxide	Molecular weight	Weight %
BeO	25	13.97
Al_2O_3	102	19.0
SiO_2	60	67.03

Tentukan formula kimia bagi mineral dengan komposisi kima berikut.

Unsur oksida	Berat molikul	% berat
BeO	*25*	*13.97*
Al₂O₃	*102*	*19.0*
SiO₂	*60*	*67.03*

[c]   Given Miller indices, ρ and ɸ angles for crystal faces that, in combination, intersect all crystallographic axes, calculate the axial ratios of the mineral.

Faces	ρ	φ
(110)	90°	45°
(011)	70°	0°

Diberi indeks Millers, sudut-sudut muka kristal ρ dan ɸ yang secara kombinasi memotong kesemua paksi-paksi kristalografik, kirakan nisbah paksi mineral berkenaan.

Muka	*ρ*	*φ*
(110)	*90°*	*45°*
(011)	*70°*	*0°*

(100 marks/*markah*)

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