UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EBS 209/3 - Mineralogy
[Mineralogi]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains ELEVEN 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 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.]

PART A

BAHAGIAN A

1. Answer all the following questions.

Jawab semua soalan berikut.

[a] (i) What is symmetry operation and elements? Based on the given information for each crystal models (3 models M1, M2 and M3), determine their 3-D point group (H-M) respectively.

M1 - Comprise more than 3-fold axes (normally four of them) and 3 4-fold axes without mirrors normal to the 4-fold axes.

M2 - This model does not have 3-fold and 2-fold axes, and without a mirror, however with a center of inversion point?

M3 - Does not contain more than one (1) 3-fold axes, but more than 2-fold or greater rotation axis. This crystal model is also free from having 2-fold axes normal to n-fold axes, but with n = 2-fold normal to a mirror.

Apakah itu operasi simetri dan unsur simetri? Berdasarkan maklumat yang diberikan bagi setiap model hablur (3 model - M1, M2 dan M3), sila tentukan titik kumpulan 3-D (H-M) bagi model hablur masing-masing.

M1 *- Mengandugi lebih daripada paksi-paksi 3-lipatan (biasanya sebanyak empat) dan 3 paksi 4-lipatan tanpa satah cermin normal terhadap paksi-paksi 4-lipatan.*

M2 *- Model ini tidak mengandungi paksi-paksi 3-lipatan dan 2-lipatan, dan juga tanpa satah cermin, akan tetapi mempunyai satu titik pusat salingan.*

M3 *- Tidak mempunyai lebih daripada 1 paksi-paksi 3-lipatan, tetapi mempunyai paksi-paksi putaran 2-lipatan atau lebih tinggi. Model hablur ini juga bebas daripada memiliki paksi-paksi 2-lipatan yang normal terhadap paksi-paksi n-lipatan, tetapi paksi n = 2-lipatan adalah normal terhadap satu satah cermin.*

...3/-

(ii) What are the Miller Indices of the following faces of forms having the following Weiss parameters?

(a) 6a : 1/4b : 3c minus (b) 1/2a (minus) : 1/4b : infinity c

Apakah nilai indek Miller bagi sebuah bentuk yang mempunyai parameter Weiss seperti berikut?

(a) 6a : 1/4b : 3c minus (b) 1/2a (minus) : 1/4b : infinity c

[b] (i) Although a crystal structure is an ordered arrangement of atoms on a lattice the order may be different along different directions in crystal, thus effect their properties which is known as Vectorial Properties of crystal. Please elaborate?

Meskipun suatu struktur hablur merupakan susunatur atom-atom dalam suatu kekisi, susunatur mungkin berbeza dalam arah-arah yang berlainan dalam hablur, justeru mempengaruhi sifatnya yang dikenali sebagai "Sifat-sifat vektor hablur". Sila jelaskan.

(ii) Barite ($BaSO_4$) has orthorhombic cell edges a = 7.157 Å, b = 8.884Å, and c = 5.457Å. Calculate 2θ for Cukα radiation λ = 1.5405Å) for the following X-ray diffractions: (a) (002) and (b) (110).

Barit (BaSO4) mempunyai sisian-sisian sel a = 7.157 Å, b = 8.884Å, dan c = 5.457Å. Kirakan 2θ bagi Cukα bagi ridiasi λ = 1.540Å) bagi belauan sinar-x pada (a) (002) dan (b) (110).

[c] Define density (S.G.). What are the factors that governed the specific gravity of minerals? If 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.

Takrifkan ketumpatan/graviti tentu (S.G.). Apakah faktor yang mengawal ketumpatan tentu sesuatu mineral itu? Sekiranya mineral sulfida yang lazm pirit (FeS_2) mempunyai ketumpatan 5.02 g/sm^3 dan sisian sel unit 5.42 Å. Kirakan nilai Z, iaitu bilangan unit-unit formula per sel.

(20 marks/*markah*)

2. Answer all the following questions.

[a] What is the minimum potential in kV that is required to excite Cu K-series radiation from a Cu-target X-ray tube? Absorption edge of Cu = 1.380Å. For forsterite a = 4.75; b = 10.20; c = 5.98Å. Calculate 2θ for the (201) lattice spacing for Cukα (λ = 1.5405Å).

Apakah nilai minimum keupayan dalam kV yang diperlukan bagi menguja radiasi Cu K-siri daripada tiub sinar-x dengan sasaran-Cu. Sisian penyerapan bagi kupram = 1.380Å. Bagi mineral forterite a = 4.75; b = 10.20; c = 5.98Å. Kirakan sudut 2θ bagi ruang satah kekisi (201) dengan Cukα (λ = 1.5405Å).

[b] Each mineral species has unique and identifiable physical properties. Some of them are color and streak. Elaborate these properties and which one is the most reliable characteristic?

Setiap spesies mineral mempunyai sifat-sifat fizikal yang unik dan boleh dikenalpasti. Antaranya ialah warna dan corekan. Sila perjelaskan sifat-sifat berkenaan dan yang manakah ciri lebih diyakini?

[c] Given the following mineral formulae determine the valence (charge and number) of the element labeled "X" in each formula below:

(a) $Al_6XPO_4(OH)_8.2H_2O$ (b) $X_3Al_2Si_6O_{18}$

(c) $Mg_3X_2Si_3O_{12}$ (d) $CaAl_2X_2(Al_2Si_2O_{10})$

Given P = +5

Tentukan valensi bagi formula-formula mineral (cas dan nombor) bagi unsur-unsur berlebel "X" di bawah:

(a) $Al_6XPO_4(OH)_8.2H_2O$ *(b)* $X_3Al_2Si_6O_{18}$

(c) $Mg_3X_2Si_3O_{12}$ *(d)* $CaAl_2X_2(Al_2Si_2O_{10})$

Diberikan P = +5

(20 marks/*markah*)

PART B

BAHAGIAN B

3. [a] Identify the class types (Berzelian system) that belong to the minerals given below. Also calculate the weight percent of each element (cation) oxides for the empirical formula for each mineral, and what are the total iron and magnesia content when all composition data are combined?

1) Dolomite ($CaMg(CO_3)_2$
2) Garnet ($Mg_3Al_2Si_3O_2$)
3) Brucite ($Mg(OH)_2$
4) Geothite (FeOOH)
5) Hematite (Fe_2O_3)

(Atomic weight Mg : 24.31, Al : 26.98, K : 39.10)

Kenalpastikan jenis-jenis kelas (Sistem Berzelian) kepunyaan mineral-mineral berikut. Juga tentukan peratus berat setiap element (kation) oksida bagi formula empirikal mineral-mineral itu dan apakah jumlah besi dan kandungan magnesia apabila semua data komposisi kimianya disatukan?

1) Dolomite ($CaMg(CO_3)_2$
2) Garnet ($Mg_3Al_2Si_3O_2$)
3) Brucite ($Mg(OH)_2$
4) Geothite (FeOOH)
5) Hematite (Fe_2O_3)

(Berat atom Mg : 24.31, Al : 26.98, K : 39.10)

[b] The mineral pyrope is the magnesian end-member of the garnets. It has the chemical formula $Mg_3Al_2Si_3O_{12}$. Express this a weight percents of the appropriate oxides. Meanwhile pyroxene enstatite ($MgSiO_3$) occurs in three different polymorphs. One of them is clinoenstatite (monoclinic) with cell edges a = 9.605Å, b = 8.813 and c = 5.166, β = 108.46°. Calculate the density of this mineral. Avogadro no. $6.022 \times 10^{+23}$.

Mineral pirop adalah ahli-akhir magnesia garnet yang mempunyai formula kimia $Mg_3Al_2Si_3O_{12}$. Nyatakan peratus berat oksidanya. Manakala enstatit ($MgSiO_3$) terjadi dalam tiga polimorf berbeza. Salah satunya adalah klinoenstatit (monoklinik) dengan sisi-sisi unit a = 9.605Å, b = 8.813 dan c = 5.166, β = 108.46°. Kirakan ketumpatan mineral ini? No. Avogadro ialah $6.022 \times 10^{+23}$.

(20 marks/*markah*)

4. [a] What is electro neutrality? Determine and write the electro neutrality components for mineral Albite ($AlSI_3O_8$), Perovskite ($CaTiO_3$) and Bornite (Cu_5FeS_4).

Apakah itu elektrokenutralan? Tentu dan tuliskan komponen-komponen keneutralan bagi mineral-mineral Albit ($AlSI_3O_8$), Perovskit ($CaTiO_3$) dan Bornite (Cu_5FeS_4).

[b] Define and discuss different categories of tenacity in mineral (metallic and non-metallic).

Takrif dan bincangkan kategori-kategori berlainan "kekukuhan" dalam mineral (logam dan bukan-logam).

[c] "Solid " and "Homogeneous" are the two main components in definition of a mineral. Please describe what they are really means for?

"Pepejal" dan "homogen" adalah dua komponen utama terkandung dalam definasi mineral. Perjelaskan apakah sebenar yang dimaksudkannya.

(20 marks/*markah*)

5. [a] How are minerals classified? State the name of the mineral class represented by the anion or complex anion below:

(i) $(VO_4)^{-3}$ (ii) $(PO_4)^{-3}$ (iii) $(CO_3)^{-3}$
(iv) $(MoO_4)^{-2}$ (v) $(OH)^{-1}$

Bagaimana mineral diklasifikasikan? Nyata dan namakan kelas mineral yang diwakili oleh anion dan kompleks anion berikut:

(i) $(VO_4)^{-3}$ *(ii)* $(PO_4)^{-3}$ *(iii)* $(CO_3)^{-3}$
(iv) $(MoO_4)^{-2}$ *(v)* $(OH)^{-1}$

[b] Define Axial ratio. What is the axial ratio for mineral quartz and sulphur with the following unit cell dimensions, respectively?

Quartz $a_1 = a_2 = a_3 = 4.913$ Å and $c = 5.405$ Å
Sulphur $a = 10.47$ Å, $b = 12.87$ Å and $c = 24.39$ Å,

Takrifkan nisbah Paksi. Apakah nisbah paksi bagi mineral kuarza dan sulfur dengan dimensi unit sel seperti berikut?

Kuarza $a_1 = a_2 = a_3 = 4.913$ *Å and* $c = 5.405$ *Å*
Sulfur $a = 10.47$ *Å,* $b = 12.87$ *Å and* $c = 24.39$ *Å,*

(20 marks/*markah*)

6. [a] Silicate minerals is the most abundance minerals and has been classified in accordance the structures how atoms of silicon and oxygen packed together, i.e. tetrahedral is shared to form silicate structures like island or ring. Given below formula of some silicate minerals, and please determine it silicate group.

(i) $Ca_2(Fe^{+3},Al)Al_2(SiO_4)(Si_2O_7)(OH)$

(ii) $Be_3Al_2Si_6O_{18}$

(iii) $Ca(Mg,Fe)Si_2O_6$

(iv) $Mg_3Al_2Si_3O_{12}$

(v) $K(Mg,Fe)_3(AlSi_3)O_{10}(OH)_2$

Mineral silikat adalah mineral yang terbanyak dan diklasifikasikan menurut struktur-struktur bagaimana atom-atom silikon dan oksigen digabungkan, iaitu tetrahedral dikongsikan bagi membentuk struktur silikat seperti berbentuk pulau dan cincin. Diberikan di bawah formula sekumpulan mineral silikat. Tentukan jenis kumpulan silikatnya.

(i) $Ca_2(Fe^{+3},Al)Al_2(SiO_4)(Si_2O_7)(OH)$

(ii) $Be_3Al_2Si_6O_{18}$

(iii) $Ca(Mg,Fe)Si_2O_6$

(iv) $Mg_3Al_2Si_3O_{12}$

(v) $K(Mg,Fe)_3(AlSi_3)O_{10}(OH)_2$

[b] What is the silicate and metallic mineral with the following chemical analysis:

(1) SiO_2 = 64.8%, Al_2O_3 = 18.3% and K_2O = 16.9 %
(2) FeO : 32.0%, Cr_2O_3 : 68.0%

Apakah mineral silikat dan logam yang mempunyai analisis kimia seperti berikut:

(1) SiO_2 *= 64.8%,* Al_2O_3 *= 18.3% and* K_2O *= 16.9 %*
(2) FeO : 32.0%, Cr_2O_3 *: 68.0%*

[c] State the number of atoms of each element associated with the unit cell of the mineral with the empirical formula.

$Cu_3SO_4(OH)_4$ Z = 4

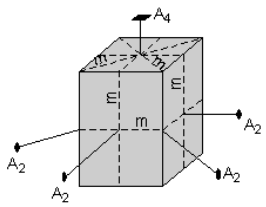
Nyatakan bilangan nombor atom bagi setiap elemen yang berasiosasi dengan sel unit mineral dengan formula ampirikal berikut:

$Cu_3SO_4(OH)_4$ Z = 4

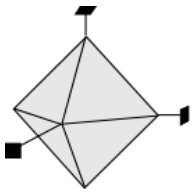
(20 marks/*markah)*

7. [a] Define Steno's law of constancy of interfacial angles. Also note down four basic of symmetries (elements and operation). Write down the symmetry contents, no of faces and type crystal forms for the given crystals.

Takrif Hukum Steno bagi keseragaman antara muka-muka. Juga tunjukkan empat simetri asas (elemen dan operasi). Tuliskan kandungan simetri, bilangan muka dan jenis "bentuk hablur" bagi hablur yang ditunjukkan.



(a)



(b)

[b] Given the following information below, determine the S.G. of the mineral aragonite, ($CaCO_3$). Show and organize your work.

SG = M x Z/ N x V	Z = 4;	N = 6.02 x 1023;
a = 4.96Å	b = 7.97Å	c = 5.74Å

Berdasarkan maklumat yang diberikan tentukan nilai graviti tentu (S.G.) bagi mineral aragonite ($CaCO_3$). Tunjukan jalan kerja anda.

SG = M x Z/ N x V	*Z = 4;*	*N = 6.02 x 1023;*
a = 4.96Å	*b = 7.97Å*	*c = 5.74Å*

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[c] Briefly define or describe the following which are inter-related to mineral crystallography.

1. Motif 2. Unit cell 3. Lattice and 4. Crystal

Secara ringkas jelaskan pengertian perkara-perkara berikut yang berkait rapat dalam kristalografi mineral.

1. Motif 2. Unit cell 3. Lattice dan 4. Crystal

(20 marks/*markah)*

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