UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2007/2008

October/November 2007

EBS 209/3 - Mineralogy
[Mineralogi]

Duration : 3 hours
[Masa : 3 jam]

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

This paper contains SEVEN questions.
[Kertas soalan ini mengandungi TUJUH soalan.]

Instructions: Answer any **FIVE** questions. If a candidate answers more than five questions, only the first five answers will be examined and awarded marks.
*[**Arahan:** Jawab **LIMA** soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

Answer to any question must start on a new page.
[Mulakan jawapan anda untuk setiap 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.]

1. Attempt any **four (4)** of the following questions.

[a] Determine the parameters (face intercepts) of a single face constituting a form which intersects the crystallographic axes at the following distances measured from the vortex of the unit cell of the mineral.

Distances of intercept of axes from vortex: a = (minus coordinate intercept) 2.56 Å; b = 35.72Å; c = 7.37Å. Unit cell dimensions measured from same vortex: a = 5.13 Å; b = 8.93 Å; c = 7.37 Å.

Determine the Miller Indices for the parameters of the above.

[b] How many faces comprise in?

(i) ditrigonal pyramid (ii) hextetrahedron

(iii) pyritohedron (iv) dihexagonal prism

[c] State the number of atoms of each element associated with the unit cell of the mineral with the empirical formula, $Cu_3SO_4(OH)_4Z = 4$?

[d] Briefly discuss the elemental composition of the earth crust.

[e] Given the following element oxide information below, determine the formula of the mineral. The ratio x:y of (OH)X and yH_2O = 6:5 in the formula. Factoring during the problem is important. Fill in the formula in the blank space below. Formula with all water as

YH_2O _____ = $Na_2O + 2CaO + 5B_2O_3 + 16H_2O$

(20 marks)

1. *Jawab mana-mana* ***empat (4)*** *soalan berikut.*

[a] *Tentukan parameter-parameter (pintasan satah) suatu satah tunggal yang mengandungi bentuk yang memotong paksi-paksi kristalografi pada jarak-jarak berikut yang diukur dari vorteks unit sel mineral.*

Jarak pintasan paksi-paksi dari vorteks: a = (minus coordinate intercept) 2.56 Å; b = 35.72Å; c = 7.37Å . Dimensi unit sel yang diukur dari vorteks yang sama: a = 5.13 Å; b = 8.93 Å; c = 7.37 Å.

Tentukan indeks Miller bagi parameters-parameter di atas.

[b] *Berapa bilangan muka yang terdapat pada:*

(i)	*ditrigonal pyramid*	*(ii)*	*hextetrahedron*
(iii)	*pyritohedron*	*(iv)*	*dihexagonal prism*

[c] *Nyatakan bilangan atom untuk setiap elemen yang berasoisaisi dengan unit sel mineral dengan formula emperik,* $Cu_3SO_4(OH)_4$ *Z = 4.*

[d] *Secara ringkas bincangkan komposisi umum kerak bumi.*

[e] *Tentukan formula mineral bagi maklumat elemen oksida yang disertakan. Dalam formula, nisbah xy bagi (OH)X dan* yH_2O *= 6.5. Pemfakturan semasa penyelesaian adalah mustahak. Tuliskan formula seperti dalam ruang kosong dibawah, iaitu formula dengan kandungan air?*

YH_2O _____ $= Na_2O + 2CaO + 5B_2O_3 + 16H_2O$

(20 markah)

2. Attempt any **four (4)** of the followings.

[a] Calculate the formula for the mineral which has the following weight % composition: Ag^{+1} = 65.4% S^{-2} = 19.4% As^{+3} = 15.2%

[b] Discuss the meaning of "graphical representation of Mineral Composition".

[c] What is electro neutrality? Determine and write the electro neutrality components for mineral Perovskite ($CaTiO_3$), Fosterite (Mg_2SiO_4) and Wollastonit ($CaSiO_3$).

[d] Crystal faces can be defined by their intercepts on the crystal axes. Write down the general axial ratios for crystal belong to system of, hexagonal, isometric, tetragonal, and triclinic.

[e] What is axial ratio? Determine the axial ratio and crystal system for the following mineral based on given the cell size (Å).

(i) a : 4.758, b : 10.2140 and c : 5.984 (Olivin)

(ii) a : 5.25, c : 10.32 (Chalcopyrite)

(iii) a : 4.84, c : 15.95 (Dolomite - with 6-fold axis)

(20 marks)

2. *Jawab mana-mana **empat (4)** soalan berikut.*

[a] *Kirakan formula mineral yang mempunyai peratus komposisi seperti berikut:*
$Ag^{+1} = 65.4\%$ $S^{2} = 19.4\%$ $As^{+3} = 15.2\%$

[b] *Bincangkan maksud "Perwakilan komposisi mineral bergrafik".*

[c] *Apakah itu elektro kenutralan? Tentu dan tuliskan komponen-komponen elektro keneutralan bagi mineral-mineral Pervskites ($CaTiO_3$), Fosterite ($CaMgSi_2O_6$) dan Wollastonit ($CaSiO_3$).*

[d] *Satah hablur boleh diungkap oleh (jarak-jarak) pintasan yang memotongi pada paksi-paksi hablur. Tuliskan nisbah-nisbah paksi umum bagi sistem-sistem hablur, heksagonal, isometrik, tetragonal.dan triklinik.*

[e] *Apakah itu nisbah paksi? Tentukan nisbah paksi dan sistem hablur bagi mineral-mineral yang mempunyai unit saiz seperti berikut berasaskan kepada saiz unit sel (Å) yang diberikan.*

(i) *a : 4.758, b : 10.2140 dan c : 5.984 (Olivin)*

(ii) *a : 5.25, c : 10.32 (Kalkopirit)*

(iii) *a : 4.84, c : 15.95 (Dolomit - dengan 6-paksi lipatan)*

(20 markah)

3. Answer any **four (4)** of the following questions.

[a] State the name of each mineral class represented by the following anions composition (polyanion):

a. $(MoO_4)^{-2}$ b. $(PO_4)^{-3}$

c. S^{-2} d. $(AsO_4)^{-3}$

e. $(NO_3)^{-1}$

[b] Match the subclass of silicate with the mineral formula.

_____	1. $CaSiO_3$	a. nesosilcate
_____	2. $KMg_3AlSi_3O_{10}(OH)_2$	b. sorosilicate
_____	3. $(Mg,Fe)_3(Al,Si)_4O_{10}(OH)_2$	c. cyclosilicate
_____	4. $Zn_4Si_2O_7(OH)_2.H_2O$	d. inosilicate(single chain)
_____	5. $CaAl_2Si_7O_{18}.6H_2O$	e.inosilicate(double chain)
_____	6. $(Mg,Fe)_7Si_8O_{22}(OH)_2$	f. phyllosilicate
		g. tectosilicates

[c] Define density (specific gravity) of a mineral and briefly highlight the governing factors and the importance of this property in the mineral identification and mineral processing.

[d] Describe "vectorial properties of crystal". State two of them together with appropriate examples (type of property and mineral name) for each category.

[e] Recall that diffraction can come from any number of (hkl) planes. Determine the lattice spacing for the isometric mineral halite for the planes of (111) where a = 5.639Å. What is the 2θ for orthorhombic Barite ($BaSO_4$) with cell edges a = 7.157 Å, b = 8.884 Å and c = 5.457 Å for the following plane (021)? Assume Cukα = 1.54059Å.

(20 marks)

3. *Jawab mana-mana **empat (4)** soalan berikut.*

[a] *Namakan setiap kelas mineral yang diwakili oleh komposisi anion berikut:*

a. $(MoO_4)^{-2}$ *b.* $(PO_4)^{-3}$

c. S^{-2} *d.* $(AsO_4)^{-3}$

e. $(NO_3)^{-1}$

[b] *Padankan subkelas silikat dengan formula mineral yang diberikan.*

_____	1. $CaSiO_3$	*a. nesosilcate*
_____	2. $KMg_3AlSi_3O_{10}(OH)_2$	*b. sorosilicate*
_____	3. $(Mg,Fe)_3(Al,Si)_4O_{10}(OH)_2$	*c. cyclosilicate*
_____	4. $Zn_4Si_2O_7(OH)_2.H_2O$	*d. inosilicate(single chain)*
_____	5. $CaAl_2Si_7O_{18}.6H_2O$	*e.inosilicate(double chain)*
_____	6. $(Mg,Fe)_7Si_8O_{22}(OH)_2$	*f. phyllosilicate*
		g. tectosilicates

[c] *Takrifkan ketumpatan (graviti tentu) suatu mineral dan secara ringkas perjelaskan faktor-faktor lazim yang mengawal sifat itu serta kepentingannya kepada pengecaman mineral dan pemprosesan mineral.*

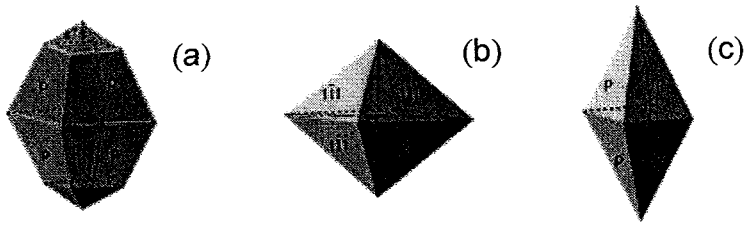
[d] *Perjelaskan "sifat vektor" suatu hablur. Nyatakan kedua jenisnya beserta contoh-contoh yang bersesuaian (sifat dan nama mineral) untuk setiap kategori itu.*

[e] *Harus diingat, belauan boleh terjadi pada mana-mana satah (hkl). Tentukan sela kekisi mineral isometri halit bagi satah-satah (111) iaitu dengan* $a = 5.639Å$. *Apakah nilai* 2θ *untuk mineral ortorombik Barite* $(BaSO_4)$ *dengan sisi unit sel* $a = 7.157$ Å, $b = 8.884$ Å *dan* $c = 5.457$ Å *pada kedudukan satah (021) dengan nilai Cuk*$\alpha = 1.54059Å$*?*

(20 markah)

4. Attempt any **four (4)** of the following questions.

[a] Determine the types of crystal systems and classes for the given crystal models below.



[b] Minerals are made-up of 3-dimensional array of atoms arranged in an orderly fashion which make up the chemical elements. Briefly discuss atom in term of their composition, charge state and isotope?

[c] The classification system of minerals, known as the Berzelian system, places mineral into broad classes according to large-sized anions that serve as the fundamental framework unit. On this basis, write the fundamental framework for the following non-silicate minerals together with appropriate mineral examples.

(i) Oxides (iii) Hydroxides (v) Carbonates
(ii) Sulphates (iv) Phosphates

[d] What is X-ray? What is the minimum potential in kV required to excite Cu k-series radiation from a Cu-target X-ray tube. Given light velocity (c) = 3.0×10^{8} m/s; 1 electron volt = 1.6016×10^{-19} joule; Planck's constant (h) = 6.6×10^{-34} joule-second. Adsorption edge of Cu = 1.380 Å.

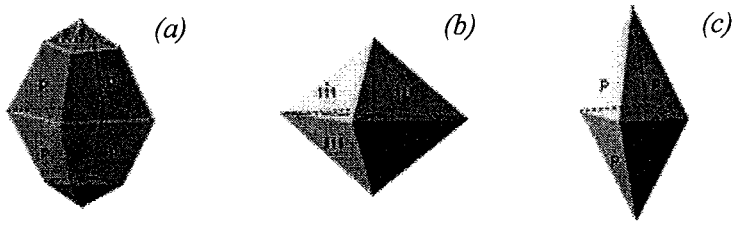
[e] Calculate the weight (%) of the elements in the mineral of Anhydrite ($CaSO_4$) and Jadeite ($NaAlSi_2O_6$), and also state the name of each of the following cation oxides.

(i) Ti_2O (iii) Al_2O_3
(ii) SiO_2 (iv) Na_2O

(20 marks)

4. *Jawab mana-mana* ***empat (4)*** *soalan berikut.*

[a] Untuk model hablur yang ditunjukkan di bawah, tentukan sistem hablur dan kelasnya.



[b] Mineral dibentuk oleh susunan 3-dimensi atom-atom dalam corak teratur elemen-elemen tertentu kimia. Secara ringkas bincangkan apakah itu atom daripada aspek komposisi, keadaan caj dan isotop?

[c] Pengelasan mineral yang dikenali sebagai sistem Berzelian yang berpandukan kepada anion-anion bersaiz besar yang menyediakan unit rangka bina asas telah meletakkan mineral dalam kelas-kelas tertentu. Berasaskan pendekatan ini tuliskan rangka bina asas bagi mineral-mineral bukan silikat berikut beserta contoh-contoh bersesuaian.

(i)	*Fosfat*	*(iii)*	*Hidroksida*	*(v)*	*Karbonat*
(ii)	*Sulfat*	*(iv)*	*Oksida*		

[d] Apakah itu X-ray? Apakah keupayaan minimum dalam kV yang diperlukan untuk menguja radiasi Cu K-siri daripada sebuah tiub sinar-X sasaran kupram? Diberikan bahawa halaju cahaya (c) = 3.0 x 10^8 m/s; 1 elektron volt = 1.6016 x 10^{-19} joule; Pemalar Planck (h) = 6.6 x 10^{-34} joule-saat. Nilai serapan sisi kupram (Cu) ialah 1.380 Å).

[e] Kirakan peratus berat elemen-elemen dalam mineral kalkopirit ($CuFeS_2$) dan Olivin (Mg_2SiO_4). Sila nyatakan juga nama-nama oksida kation yang diberikan di bawah ini.

(i)	TiO_2	*(iii)*	CaO
(ii)	SiO_2	*(iv)*	Na_2O

(20 markah)

5. Answer any **four (4)** of the following.

[a] For each crystal forms below, describe and show (diagram) the faces belong to these forms.

(i) Diteragonal Prisms
(ii) Teragonal prism
(iii) Hexagonal dipyramid
(iv) Dome

[b] Many common mineral show polymorphisms. Define polymorphism. Name and briefly discuss the two most common polymorphisms of mineral.

[c] Compositional variation in mineral means "not necessarily fixed" and often referred to solid solution. Briefly discuss this solid solution phenomenon and also state 3 types of them.

[d] Given the following mineral formulas, determine the valence (charge and number) of the element listed as "**X**" in each formula.

(i) $Cu_5\mathbf{X}S_4$ (Bornite)
(ii) $Na_2\mathbf{X}B_4O_5(OH)_4.8H_2O$ (Borax)
(iii) $Ca_5(\mathbf{X}O_4)_3Cl$ (Chlorapatite)
(iv) $Ba\mathbf{X}S_3O_9$ (Benitonite)

[e] A spodumen ($LiAlSi_2O_6$) of monoclinic, 2/m mineral has unit cell dimension, where = 9.52Å, b = 8.32Å, c = 5.25Å and $\beta = 110^o$. There are four formula units (Z) per cell. Calculate the density (ρ) of this mineral. Atomic weight of Li is 45.

(20 marks)

5. *Jawab mana-mana* ***empat (4)*** *soalan berikut.*

[a] *Untuk setiap bentuk hablur berikut, perihal dan illustrasikan (rajah) satah-satah muka yang dimiliki oleh bentuk-bentuk tersebut.*

(i) *Diteragonal Prisms*
(ii) *Teragonal prism*
(iii) *Hexagonal dipyramid*
(iv) *Dome*

[b] *Kebanyakan mineral lazimnya menunjukkan polimorfisma. Takrif polimorfisma. Nama dan secara ringkas bincangkan dua jenis polimorfisma yang lazim ditemui.*

[c] *Variasi komposisi dalam mineral bermaksud "tidak semestinya tetap" dan kerapkali berkait rapat dengan larutan pepejal. Secara ringkas terangkan maksud fenomena larutan pepejal itu dan nyatakan tiga daripadanya.*

[d] *Untuk formula-formula mineral berikut, tentukan valensi (caj dan nombor) elemen-elemen bertanda "X" dalam setiap formula.*

(i) Cu_5XS_4 *(Bornite)*
(ii) $Na_2XB_4O_5(OH)_4.8H_2O$ *(Borax)*
(iii) $Ca_5(XO_4)_3Cl$ *(Chlorapatite)*
(iv) $BaXS_3O_9$ *(Benitonite)*

[e] *Mineral monoklinik, 2/m spodumen ($LiAlSi_2O_6$), mempunyai dimensi sel unit, iaitu $a = 9.52Å$, $b = 8.32Å$, $c = 5.25Å$ and $\beta = 110^o$. Terdapat empat formula unit (Z) untuk setiap sel. Tentukan ketumpatan (ρ) mineral ini. Berat atom Litium ialah 45.*

(20 markah)

6. Attempt **four (4)** the following questions.

[a] Determine the formulas and identify the minerals represented by the following analyses (wt %).

(i) Al_2O_3 : 39.5, SiO_2 : 46.5, H_2O : 14.0

(ii) Na_2O : 15.4, Al_2O_3 : 25.2, SiO_2 : 59.4

(iii) SiO_2 : 51.5, FeO : 30.8, MgO : 17.7

[b] Zircon $ZrSiO_4$ is 4/m2/m2/m mineral, has density of 4.68 g/cm^3 and Z of 8, dimension. An ideal zircon always contains 67.2% ZrO_2. Avogadro no. $6.022 \times 10^{+23}$.

(i) Calculate the cell edge and specific gravity of zircon.

(ii) What is the amount of (silica) SiO_2 to form a mole of zircon?

[c] Define colour of mineral. State and describes the differences or similarities between colour and streaks. Give appropriate examples to support your answers.

[d] The fundamental unit on which the structure of all silicates is based on the polymerization (linking) of "tetrahedra". Draw the following silicate structures and example of mineral.

(i) Nesosilicates

(ii) Sorosilicates

(iii) Inosilicates

[e] What is the basis of division in the classification scheme of mineral for mineral classes, subclasses, groups, series, and varieties?

(20 marks)

6. *Jawab mana-mana* ***empat (4)*** *soalan berikut.*

[a] *Tentukan formula dan kenalpastikan mineral-mineral berikut berasaskan kepada analisa komposisi (wt %) yang diberikan.*

(i) Al_2O_3 : 39.5, SiO_2 : 46.5, H_2O : 14.0

(ii) Na_2O : 15.4, Al_2O_3 : 25.2, SiO_2 : 59.4

(iii) SiO_2 : 51.5, FeO : 30.8, MgO : 17.7

[b] *Mineral Zirkon,* $ZrSiO_4$, *4/m, 2/m, 2/m mempunyai ketumpatan 4.68* g/cm^2 *dan dimensi Z = 8, zirkon tulin lazim mengandungi 67.2* ZrO_2. *Avogadro no.* $6.022 \times 10^{+23}$.

(i) *Kirakan sisian sel dan gravity tentu zircon*

(ii) *Apakah kandungan (silika)* SiO_2 *diperlu untuk membentuk 1 mol zirkon?*

[c] *Takrif warna dalam mineral? Nyata sertakan perbezaan atau persamaan antara warna dan corekan. Berikan contoh-contoh bersesuaian untuk menyokong jawapan anda.*

[d] *Unit asas kepada pembentukan mineral-mineral silikat adalah berdasarkan kepada polimerisasi (rantaian) "tetrahedra". Lakarkan struktur-struktur silikat berikut serta berikan contoh mineralnya.*

(i) *Nesosilkat*

(ii) *Soroilikat*

(iii) *Inosilikat*

[e] *Apakah asas pembahagian skema pengelasan mineral iaitu daripada aspek kelas mineral, subkelas, kumpulan, siri dan variasi?*

(20 markah)

7. Attempt any **four (4)** of the following questions.

[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) $CaAl_2Si_2O_7(OH)_2$

(ii) $Be_3Al_2Si_6O_{18}$

[b] Given the following parameters of a single face of a form (face intercepts), determine the Miller Indices of each face below:

(i) 2a(minus): 4b: 4c

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

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

[c] Match the columns below

_____	1. K-feldspar group	a. nesosilicate
_____	2. mica group	b. sorosilicate
_____	3. amphibole group	c. cyclosilicate
_____	4. pyroxene group	d. inosilicate (single chain)
_____	5. garnet group	e. inosilicate (double chain)
_____	6. plagioclase feldspar	f. phyllosilicate
		g. tectosilicate

[d] Define lusture in mineral. What are the differences between metallic luster and submetallic luster?

[e] For the given elements, identify those known as native elements of metal and semi-metal categories.

C, B, F, Na, Fe, S, Ag, Cs, Ba, As, Au, Re and Zn

(20 marks)

7. *Jawab mana-mana* ***empat (4)*** *soalan berikut.*

[a] *Dengan menggunakan formula umum silikat,* $X_mY_n(Z_pO_q)w_r$, *padankan setiap elemen yang sepadan atau sekumpulan elemen dan subskrip dalam setiap formula mineral di bawah:*

(i) $CaAl_2Si_2O_7(OH)_2$

(ii) $Be_3Al_2Si_6O_{18}$

[b] *Berikut adalah diberikan parameter-parameter pada satu muka suatu bentuk (pintasan satah muka), tentukan indek Miller bagi setiap muka di bawah.*

(i) *2a(minus): 4b: 4c*

(ii) *1/4a: 1/2b(minus): infinity c*

(iii) *3a: 1/4b: 6c(minus)*

[c] *Padankan kumpulan mineral berikut dengan silikatnya.*

_____	*1. K-feldspar group*	*a. nesosilicate*
_____	*2. mica group*	*b. sorosilicate*
_____	*3. amphibole group*	*c. cyclosilicate*
_____	*4. pyroxene group*	*d. inosilicate (single chain)*
_____	*5. garnet group*	*e. inosilicate (double chain)*
_____	*6. plagioclase feldspar*	*f. phyllosilicate*
		g. tectosilicate

[d] *Takrif kilauan pada mineral. Apakah perbezaan/persamaan antara kilauan logam dan separa logam?*

[e] *Untuk unsur-unsur yang diberikan di bawah, kenlapasti unsur-unsur jati daripada kategori jati dan separa jati.*

C, B, Cu, F, Na, Fe, S, Ag, Cs, Ba, As, Au, Re and Zn

(20 markah)

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