
UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2006/2007
*Peperiksaan Semester Pertama
Sidang Akademik 2006/2007*

Oktober/November 2006

EBS 209/3 - Mineralogy
EBS 209/3 - Mineralogi

Time : 3 hours
Masa : 3 jam

Please ensure that this paper consists of FIFTEEN printed pages before you proceed with the examination.

This paper contains SEVEN questions.

Answer any FIVE questions. If a candidate answers more than five questions, only the first five answers will be examined and awarded marks.

Answer to any question must start on a new page.

All questions could be answered in Bahasa Malaysia or English.

Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA BELAS muka surat yang bercetak sebelum anda memulakan peperiksaan.

Kertas soalan ini mengandungi TUJUH soalan.

Jawab LIMA soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

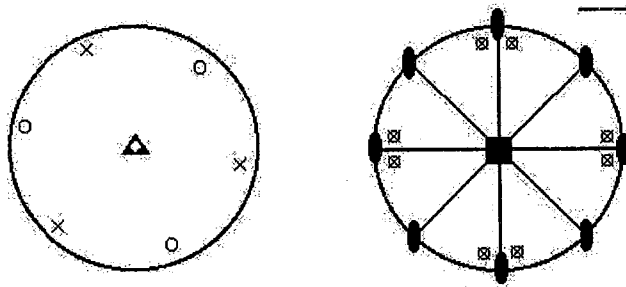
Semua soalan boleh dijawab samada dalam Bahasa Malaysia atau Bahasa Inggeris.

Answer only FIVE (5) of the following questions.

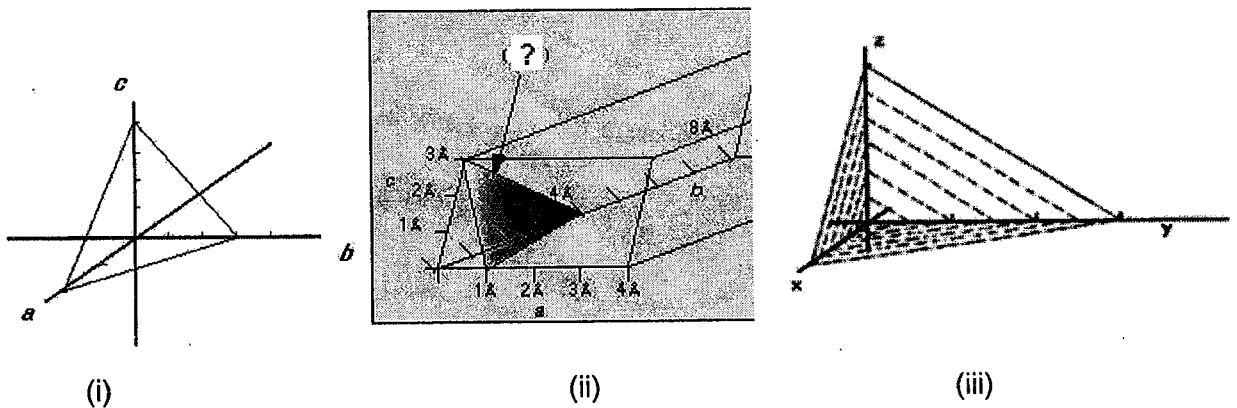
Jawab hanya mana-mana LIMA (5) soalan yang berikut.

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

- [a] For each of the following point-group symmetry diagrams, identify the point group (crystal class), crystal system, and give the multiplicity (of a general face).



- [b] Illustrated below are the three (Fig. 1 to 3) different crystallographic planes (crystal face) that intercepts at different unit length (Weiss parameter). Determine the Miller indices of these planes.

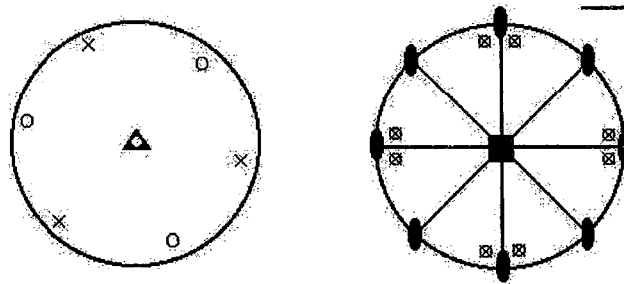


- [c] There are two ways of X-ray uses in mineralogy. State and briefly discuss their principle and application. The lattice spacing for the (-2 2 1) X-ray diffraction line (reflection) is 3.0215\AA . Calculate the 2θ angle for the reflection using Cu $k\alpha$ radiation ($k\alpha = 1.5405\text{\AA}$).

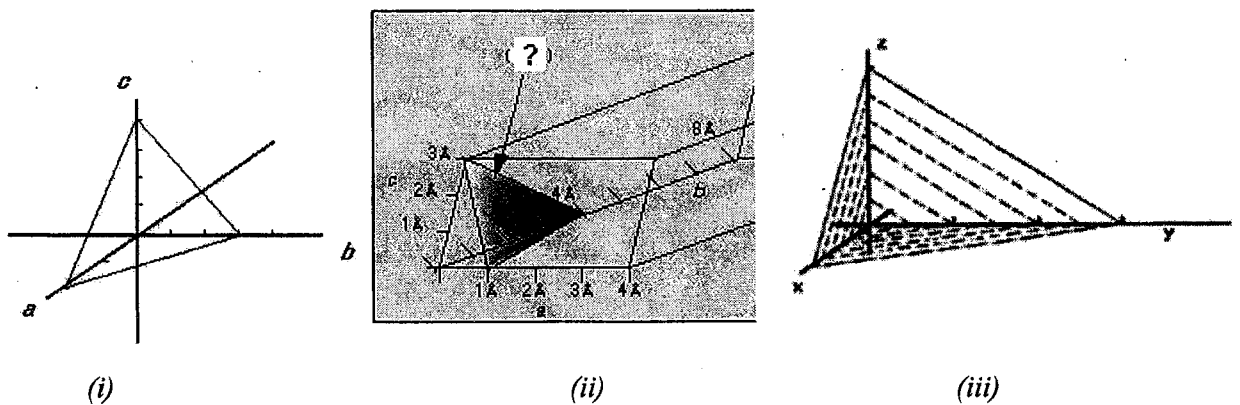
- [d] Briefly discuss the composition of the earth crust.
- [e] The mineral omphacite is a pyroxene that is intermediate in composition between jadeite ($\text{NaAlSi}_2\text{O}_6$) and diopside ($\text{CaMgSi}_2\text{O}_6$). Calculate the composition in weight percent oxides of an omphacite that is 60 mol percent diopside and 40 mol percent jadeite.
- (20 marks)

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

[a] Untuk setiap tatarajah simetri kumpulan-titik berikut, kenalpastikan kumpulan titik (kelas hablur), sistem hablur serta bilangan muka (satah umum).



[b] Berikut adalah ilustrasi (Rajah (i) hingga (iii)) tiga satah-satah (muka hablur) kristalografi dengan unit-unit jarak pintasan berlainan. Tentukan indeks Miller bagi satah-satah tersebut.



- [c] Terdapat dua pendekatan penggunaan belauan sinar-X dalam mineralogi. Nyata dan terangkan secara ringkas prinsip dan penggunaan (aplikasi) pendekatan tersebut. Jarak kekisi bagi satah $(-2\ 2\ 1)$ suatu belauan sinar-X (balikan) ialah 3.0215\AA . Kirakan sudut 2θ bagi belauan tersebut yang menggunakan radiasi Cu $k\alpha$ ($k\alpha = 1.5405\text{\AA}$).
- [d] Secara ringkas bincangkan komposisi umum kerak bumi.
- [e] Mineral omphacite merupakan piroksin yang berkomposisi pertengahan di antara jadeit ($\text{NaAlSi}_2\text{O}_6$) dan diopsid ($\text{CaMgSi}_2\text{O}_6$). Kirakan peratusan berat oksida omphacite yang merupakan 60 peratusan mol diopsid dan 40 peratusan mol jadeit.

(20 markah)

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

- [a] What is crystal habit? State and illustrate five (5) common crystal habits.
- [b] Crystal faces can be defined by their intercepts on the crystal axes. Write down the general axial ratios for crystal belong to system of triclinic, hexagonal, isometric and tetragonal.
- [c] What is electro neutrality? Determine and write the electro neutrality components for mineral Orthoclase (KAlSi_3O_8) and Wollastonite (CaSiO_3).
- [d] Define tenacity and describe four (4) common types or categories of this property. What are differences between sectile and malleable?

[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:5.299, c:10.434
- (ii) a:4.758, b:10.214, c:5.984
- (iii) a:3.618, c:5.034 (This mineral contains 6-fold axis)

(20 marks)

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

[a] Apakah itu tabiat hablur (crystal habit)? Nyata dan ilustrasikan 5 jenis tabiat hablur yang lazim beserta contoh-contoh mineral.

[b] Satah hablur boleh diungkap oleh (jarak-jarak) pintasan yang memotong pada paksi-paksi hablur. Tuliskan nisbah-nisbah paksi umum bagi sistem-sistem hablur triklinik, heksagonal, isometri dan tetragonal.

[c] Apakah itu elektro kenutralan? Tentu dan tuliskan komponen-komponen elektro keneutralan bagi mineral-mineral Ortoklas ($KAlSi_3O_8$), Diopsid ($CaMgSi_2O_6$) dan Wollastonit ($CaSiO_3$).

[d] Takrifkan pengukuhan (tenacity) serta perelaskan empat (4) jenis atau kategori utama kebolehtempaan. Apakah perbezaan di antara sectile dan kebolehtempaan (malleable)?

[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:5.299, c:10.434
- (ii) a:4.758, b:10.214, c:5.984
- (iii) a:3.618, c:5.034 (Mineral ini mengandungi paksi 6-lipatan)

(20 markah)

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

- [a] Minerals were formed by a number of processes mechanisms. State and briefly discuss such major mechanism processes.
- [b] Describes "vectorial properties of crystal". State two of them together with appropriate examples (type of property and mineral name) for each category.
- [c] Defines density (specific gravity) of a mineral and briefly highlight the governing factors and the important of this property in the mineral identification and mineral processing.
- [d] Recall that diffraction can come from any number of (hkl) planes. Determines the lattice spacing for the isometric mineral halite for the planes of (111) where $a = 5.639\text{\AA}$. What is the 2θ for orthorhombic Barite (BaSO_4) with cell edges $a = 7.157\text{\AA}$, $b = 8.884\text{\AA}$ and $c = 5.457\text{\AA}$ for the following plane (021)? Where $CuK\alpha = 1.54059\text{\AA}$?
- [e] Note that the 32 classes of minerals are divided into six crystal systems. This classification are defines by symmetrical content of the crystal which possess unique faces or group of faces known as crystal forms. Name all these crystal systems and theirs respective and unique symmetrical contents.

(20 marks)

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

- [a] Mineral terbentuk di bawah beberapa proses mekanisma tertentu. Nyata dan secara ringkas perelaskan mekanisma proses utama pembentukan mineral ini.
- [b] Huraikan pengertian sifat vektor hablur ("vectorial properties of crystal"). Nyatakan kedua-dua jenis sifat vektor berkenaan beserta contoh-contoh bersesuaian (Sifat dan nama mineral).
- [c] Takrifkan ketumpatan (graviti tentu) suatu mineral dan secara ringkas perelaskan faktor-faktor lazim yang mengawal sifat itu serta kepentingannya kepada pengesanan mineral dan pemprosesan mineral.
- [d] Harus diingat, belauan boleh terjadi pada mana-mana satah (hkl). Tentukan sela kekisi mineral isometri halit bagi satah-satah (111) iaitu dengan $a = 5.639 \text{ \AA}$. Apakah nilai 2θ untuk mineral ortorombik Barite (BaSO_4) dengan sisi unit sel $a = 7.157 \text{ \AA}$, $b = 8.884 \text{ \AA}$ dan $c = 5.457 \text{ \AA}$ pada kedudukan satah (021) dengan nilai $CuK\alpha = 1.54059 \text{ \AA}$?
- [e] Perlu diingat bahawa kesemua 32 kelas mineral adalah tergolong dalam salah satu enam sistem hablur. Pengelasan ini ditakrif atau dikaitkan oleh kandungan simetri hablur itu yang mempunyai muka-muka unik atau sekumpulan muka-muka yang diketahui sebagai bentuk hablur ("crystal forms"). Namakan kesemua sistem hablur ini beserta kandungan simetri uniknya masing-masing.

(20 markah)

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

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

[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) Phosphates | (iv) Hydroxides |
| (ii) Sulphates | (v) Oxides |
| (iii) Carbonates | |

[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 $(c) = 3.0 \times 10^8$ m/s; 1 electron volt = 1.6016×10^{-19} joule; Planck's constant $(h) = 6.6 \times 10^{-34}$ joule-second. Adsorption edge of Cu = 1.380 Å.

[e] Calculate the weight (%) of the elements in the mineral of chalcopyrite (CuFeS_2) and Olivin (Mg_2SiO_4), and also state the name of each of the following cation oxides.

- | | |
|----------------------------|------------------------------|
| (i) K_2O | (iii) CaO |
| (ii) Na_2O | (iv) Al_2O_3 |

(20 marks)

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

[a] Kebanyakan mineral lazimnya menunjukkan polimorfisma. Takrifkan polimorfisma. Nama dan bincangkan secara ringkas dua jenis utama polimorfisma mineral.

[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 | (iv) Hidroksida |
| (ii) Sulfat | (v) Oksida |
| (iii) Karbonat | |

[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) = 3.0×10^8 m/s; 1 elektron volt = 1.6016×10^{-19} joule; Pemalar Planck (h) = 6.6×10^{-34} joule-saat. Nilai serapan sisi kupram (Cu) ialah 1.380 \AA .

[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) K_2O | (iii) CaO |
| (ii) Na_2O | (iv) Al_2O_3 |

(20 markah)

...10/-

70
200

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 | (iii) Hexagonal dipyramid |
| (ii) Teragonal prism | (iv) Dome |

[b] Name a mineral that has the following values of Mohs' hardness.

- | | |
|--------------|-------------|
| A. 10. _____ | B. 8. _____ |
| C. 7. _____ | D. 5. _____ |
| E. 4. _____ | F. 2. _____ |
| G. 1. _____ | |

[c] Compositional variation in mineral means "not necessarily fixed" and often referred to solid solution. Briefly discuss this solid solution phenomenon and also stated 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) ZnX_2O_4 | (iii) $NaXB_5O_6(OH)_6 \cdot 5H_2O$ |
| (ii) $Pb_5(XO_4)_3Cl$ | (iv) $Mg_3X_2Si_3O_{12}$ |

[e] A pyroxene of monoclinic mineral has unit cell dimension, where $a = 9.6214\text{\AA}$, $b = 8.8303\text{\AA}$, $c = 5.1761\text{\AA}$ and $\beta = 108.39^\circ$. There are four formula units (Z) per cell. Calculate the density (ρ) of this sample?

(20 marks)

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

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

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

[b] Namakan mineral yang mempunyai nilai kekerasan Mohs seperti berikut.

- | | |
|--------------|-------------|
| A. 10. _____ | B. 8. _____ |
| C. 7. _____ | D. 5. _____ |
| E. 4. _____ | F. 2. _____ |
| G. 1. _____ | |

[c] Variasi komposisi dalam mineral bermaksud "tidak semestinya tetap" dan kerap kali 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) ZnX_2O_4 | (iii) $NaXB_5O_6(OH)_6 \cdot 5H_2O$ |
| (ii) $Pb_5(XO_4)_3Cl$ | (iv) $Mg_3X_2Si_3O_{12}$ |

[e] Untuk mineral piroksin monoklinik yang mempunyai dimensi unit sel, iaitu $a = 9.6214\text{\AA}$, $b = 8.8303\text{\AA}$, $c = 5.1761\text{\AA}$ dan $\beta = 108.39^\circ$ beserta empat unit formula (Z) setiap sel, kirakan nilai ketumpatannya (ρ).

(20 markah)

6. Attempts four (4) the following questions.

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

(i) Cu: 63.3, Fe: 11.1, S: 25.6

(ii) SiO₂: 38.0, Al₂O₃: 21.5, FeO: 26.6, MgO: 6.3, MnO: 7.6

(iii) SiO₂: 51.5, FeO: 30.8, MgO: 17.7

[b] The garnet end-member pyrope Mg₃Al₂Si₃O₁₂ is cubic, has density of 3.58 g/cm³ and Z of 8, whilst calcite has a = 4.96Å b = 7.97Å c = 5.74Å dimension and Z = 4. Avogadro no. 6.022 x 10²³.

(i) Calculate the cubic cell edge and specific gravity of garnet

(ii) Specific gravity of calcite

[c] Defines cleavage in mineral? How cleavages are described in terms of "quality" and "general forms names".

[d] State the name of each mineral class represented by the following anion composition.

(i) (MoO₄)⁻²

(ii) (PO₄)⁻³

(iii) S⁻²

(iv) (AsO₄)⁻³

(v) (NO₃)⁻¹

[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) Cu: 63.3, Fe: 11.1, S: 25.6
- (ii) SiO₂: 38.0, Al₂O₃: 21.5, FeO: 26.6, MgO: 6.3, MnO: 7.6
- (iii) SiO₂: 51.5, FeO: 30.8, MgO: 17.7

[b] Ahli-akhir garnet Mg₃Al₂Si₃O₁₂ merupakan mineral kubik yang mempunyai nilai ketumpatan 3.58 g/cm³ dan Z = 8, manakala kalsit pula berdimensi, iaitu a = 4.96Å, b = 7.97Å, c = 5.74Å dan Z = 4. No. Avogadro ialah 6.022 x 10²³.

- (i) Kirakan nilai sisi sel kubik dan graviti tentu bagi garnet, dan
- (ii) Graviti tentu bagi kalsit

[c] Takrifkan ira dalam mineral. Bagaimana ira-ira mineral ini diterangkan (dikelaskan) dalam pengertian "kualiti" dan juga "nama-nama bentuk umum"?

[d] Nyatakan nama kelas setiap mineral beserta contoh yang diwakili oleh komposisi anion berikut.

- (i) (MoO₄)⁻²
- (ii) (PO₄)⁻³
- (iii) S⁻²
- (iv) (AsO₄)⁻³
- (v) (NO₃)⁻¹

[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, $X_m Y_n (Z_p O_q)_w r$, 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) $Be_3 Al_2 Si_6 O_{18}$
 (ii) $Ca Al_2 Si_2 O_7 (OH)_2$

[b] 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 |

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

- (i) $2a(\text{minus}) : 3b : 3c$
 (ii) $1/2a : 1/4b(\text{minus}) : \text{infinity } c$
 (iii) $6a : 1/4b : 3c(\text{minus})$

[d] Briefly discuss magnetism in mineral.

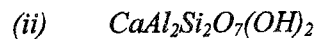
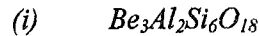
[e] Given the following element (cation) oxide weight percents, determine the formula of the mineral. The formula consists of all the water in the mineral calculated as yH_2O . Show and organize your work.

$$MgO = 31.7\%, H_2O = 4.8\%, SiO_2 = 63.5\%$$

(20 marks)

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

[a] Dengan menggunakan formula umum silikat, $X_m Y_n (Z_p O_q)_w$, padankan setiap elemen yang sepadan atau sekumpulan elemen dan subskrip dalam setiap formula mineral di bawah



[b] 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

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

(i) $2a(\text{minus}): 3b: 3c$

(ii) $1/2a: 1/4b(\text{minus}): \text{infinity } c$

(iii) $6a: 1/4b: 3c(\text{minus})$

[d] Secara ringkas bincangkan kemagnetan pada mineral.

[e] Berikut adalah diberikan peratus berat unsur (kation) suatu oksida. Tentukan formula mineral berkenaan. Formula ini mengandungi kesemua air dalam mineral yang dikirakan sebagai yH_2O . Tunjukkan secara tertib jawapan anda.

$$MgO = 31.7\%, H_2O = 4.8\%, SiO_2 = 63.5\%$$

(20 markah)