



**Tentamen 'Minerals' (BSc level 2)**

**28 October 2004**

Name \_\_\_\_\_ Student nummer \_\_\_\_\_

**YOU MUST ANSWER ALL PARTS OF QUESTIONS 1-4  
FOR QUESTION 5 CHOOSE ONLY ONE PART, EITHER A,B,C OR D.**

1

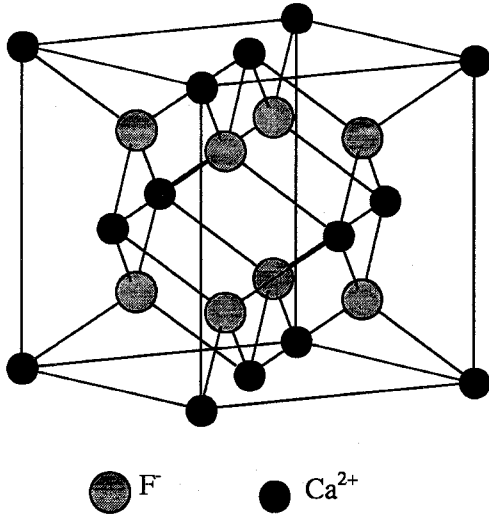
- a) List the differences between a *mineral*, a *crystalline solid* and an *amorphous solid* in the following table. Give an example of a solid material for each category:

Mineral	Crystalline solid	Amorphous solid
Example:	Example:	Example:

- a) A crystal structure consists of a \_\_\_\_\_ and a \_\_\_\_\_
- b) Why can't a mineral be recognized by its chemical formula alone?

2

The following crystal structure represents a close packed mineral



a) How are the tetrahedral sites occupied in this structure?

b) What type of packing does this structure represent?

c) and which mineral is it named after?

c) How many layers of close packed atoms are there before the structure repeats?

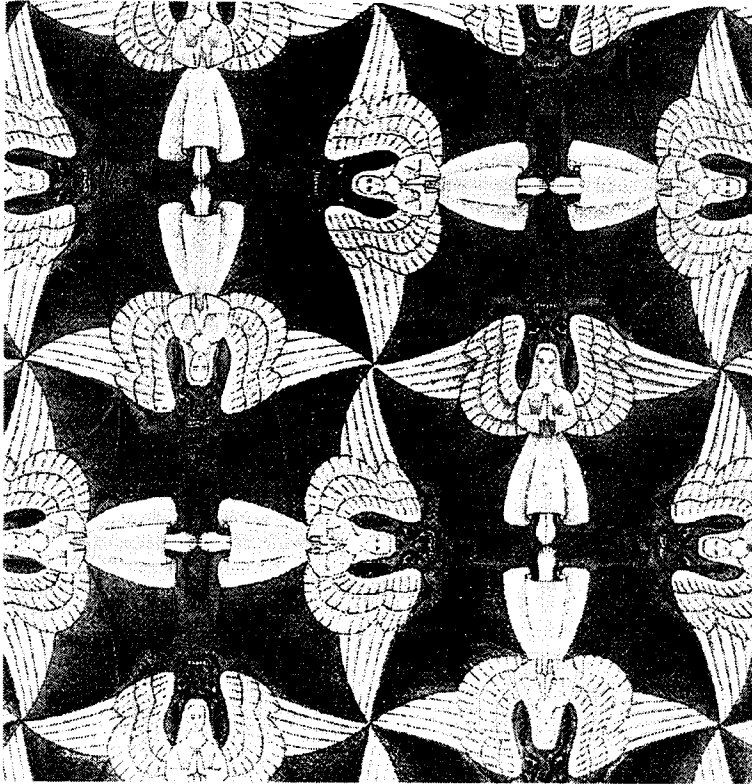
d) What is the structural difference between the close packed structure given above and that of sphalerite ( $\text{ZnS}$ )?

e) Which property of a cation controls the type of interstitial site that it can fill in a close packed structure?

f) Silicate minerals are not close packed. Which group of silicates is the closest to being close packed?

g) Give an *optical property* of a silicate mineral that indicates approximately how close its constituent atoms are packed together

3



Look at the Escher pattern above and answer the following questions.  
Give your answers for parts a) and b) and on tracing paper.

- a) Show the 2D symmetry elements using the official symbols for rotation axes, mirror planes and glide planes on the tracing paper.
- b) Draw the boundary of the unit cell
- c) What is the plane group? *Use Appendix A at the end of this exam paper to help you.*

d) What is the multiplicity of the motif?

e) Explain the difference between a special and a general position:

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4

a) Why do we use x-rays and not optical light to determine the structure of a mineral?

b) Which process causes the mineral ruby ( $\text{Al}_2\text{O}_3$ ) to have a deep red colour?

a) Minerals show optical properties that change with respect to direction in their structure. Two of these are *pleochroism* and *birefringence*. How would you distinguish between these two properties using an optical microscope?

Which physical property leads to pleochroism?

and the variation in which physical property produces birefringence?

5

**IMPORTANT: FOR THE FOLLOWING QUESTION CHOOSE ONLY ONE PART - EITHER A, B, C OR D**

**5A OPTION A**

- a) How many bridging oxygens are present in the unit cell of an island silicate mineral?
- b) Name an example of an island silicate and give its chemical formula
- c) Describe the properties of your chosen mineral under the optical microscope and explain how these might be predicted from the general crystal group structure and/or chemical formula given above:

*Relief:*

*Cleavage:*

*Colour:*

- d) What is a *solid solution*? In your answer give the most important structural and chemical controls on this process.

Does solid solution play a role in the mineral that you have chosen above and if so which elements substitute for one another?

- e) Why are island silicate minerals more abundant in the Earth's mantle than in the crust?

**5B OPTION B**

a) How many bridging oxygens are present per  $[\text{SiO}_4]^{4-}$  tetrahedron in

(i) a single chain silicate? \_\_\_\_\_

(ii) a double chain silicate? \_\_\_\_\_

**Pyroxene is a single chain silicate mineral which has two types: orthopyroxene (opx) and clinopyroxene (cpx)**

b) Which crystal systems do ortho- and clinopyroxene fall into:

*OPX* Crystal system: \_\_\_\_\_ Conditions: a \_\_\_\_ b \_\_\_\_ c      $\alpha$  \_\_\_\_  $\beta$  \_\_\_\_  $\gamma$

*CPX* Crystal system: \_\_\_\_\_ Conditions: a \_\_\_\_ b \_\_\_\_ c      $\alpha$  \_\_\_\_  $\beta$  \_\_\_\_  $\gamma$

c) What name is given to Ca-poor clinopyroxene?

d) What happens to Ca-poor clinopyroxene as it is allowed to grow in a slowly cooling magma chamber?

e) What is *cleavage*? How can cleavage be used to help identify pyroxene under the microscope?

**5C OPTION C**

a) Sketch a cross section through a 2:1 layer silicate

b) Give the name of a mineral that is an example of a 2:1 layer silicate

c) What is a *polytype*? How many different polytypes of mica are possible?

d) Sketch a diagram of a biotite crystal showing the direction of the optic axis (c- axis). Indicate on your diagram which faces show cleavage.

e) Which crystal face in biotite shows maximum pleochroism?

**5D OPTION D**

- a) How many bridging oxygens are present per  $[\text{SiO}_4]^{4-}$  tetrahedron in a framework silicate
- b) Which *cations* play an important role in the framework silicates and why?
- c) Silica ( $\text{SiO}_2$ ) has a number of polymorphs that exist under different pressure and temperature conditions. Which phase is most stable at standard pressure and temperature conditions?

Give the properties of this mineral in hand specimen and describe the general structural and chemical reasons for these properties:

*Colour:*

*Cleavage:*

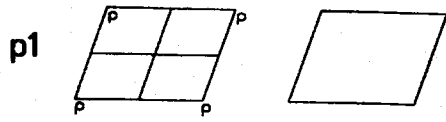
*Crystal shape and hence crystal system:*

- b) In which mineral would you expect to find a *perthite* texture?
- f) Describe the process that leads to the breakdown of the original mineral precursor and the formation of the perthite?

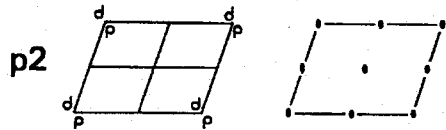


Appendix A: Two dimensional plane groups

1 Oblique

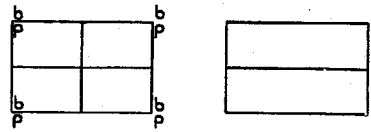


2 Oblique

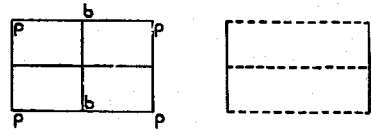


Rectangular m

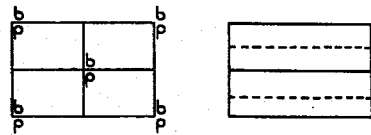
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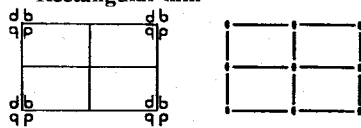


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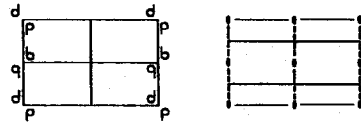


Rectangular mm

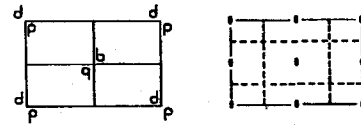
pmm



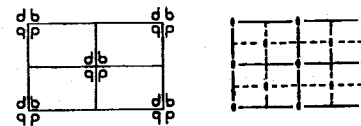
pmg



pgg

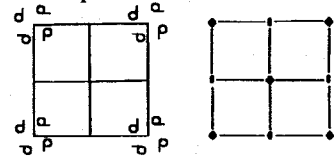


cmm



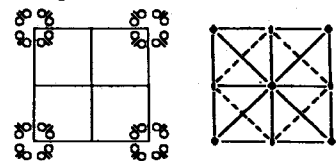
square 4

p4



square 4mm

p4m



p4g

