Tentamen 'Minerals' (BSc level 2) 10 November 2003

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

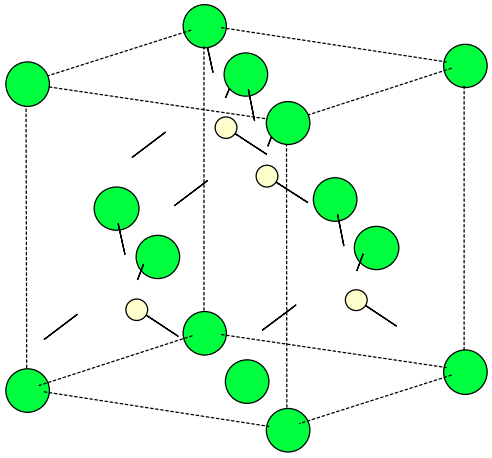
a) Define a *mineral*

b) The structure of a mineral (or crystal) is a combination of a mathematical lattice and a motif of atoms. How would you determine this structure experimentally?

c) Graphite and Diamond have the same chemical composition and chemical formula (C) but different crystal structures. Why do they have different structures?

2

The following is a type of close packed structure



a) How are the interstitial sites occupied?

b) What is the co-ordination number of the close packed atoms?

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

d) What kind of close packed structure is this ?

e) Give an example of a mineral that adopts this structure and its chemical formula

Halite (NaCl) has a similar structure to that given above but the interstitial sites are filled in a different way

f) Which is the close packed ion in Halite and why?

g) Which interstitial sites are occupied?

h) As a result of its crystal structure which crystal system does Halite fall into? What are the defining symmetry elements for this crystal system?

3

a) Explain why some minerals such as Quartz and Halite colourless whilst others such as Olivine and Pyroxene are strongly coloured

b) What is *pleochroism*?

c) Give an example of a mineral that is pleochroic.
Would you expect to see the same amount of pleochroism on all of its crystal faces? If not , why not?

4

Calcite ($CaCO_3$) shows a phenomenon called *double refraction*. It falls into the trigonal crystal system.

a) What are the crystallographic conditions (i.e. axes) for the trigonal system, including the definitive symmetry elements?

b) What does *double refraction* do to the vibration directions of light that passes though the crystal? (Describe this in words or sketch a diagram to show this effect)

c) Calcite was used in the earliest petrographic microscopes as a polarizing filter. Why are two polarizing filers used together in an optical microscope? What optical effect does this lead to? Why do isotropic minerals appear black under crossed polarised light and why does an anisotropic mineral go 'extinct' 4 times during a 360^o rotation?

5

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

5A OPTION A

a) Name an example of an island silicate and sketch how the *tetrahedra* are arranged below.

b) What is the chemical formula of this mineral? _____

c) Describe what is meant by *solid solution* and 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?

d) In what rock-types would you expect to find your chosen island silicate?

e) Island silicates are the have the highest density on average of all the silicate minerals. Why?

5B OPTION B

a) Make a sketch of the links between *tetrahedra* in a single chain silicate and show the smallest repeat unit

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

b) What are the *crystallographic* differences between opx and cpx? Give as much detail as you can.

c) How are opx and cpx *chemically* different?

d) How are cations ordered between the M1 and M2 sites in pyroxene and how does this vary with temperature?

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 1:1 layer silicate

b) How are the octahedral sheets classified in layer silicates?

c) Tetrahedral and octahedral sheets can rotate so that cations can be occupied in interstitial sites. What is this phenomenon called? Which layers are more likely to rotate: tetra- or octahedral? and why?

d) Give an example of a sheet silicate mineral with its chemical formula

Mineral _____

Formula _____

e) Why does biotite break easily along the (001) cleavage plane?

5D OPTION D

a) How are the tetrahedra linked in a framework silicate mineral?

b) Feldspars can accommodate some of the largest cations? Why?

c) What are the two main types of feldspar and in which type of rocks would you expect to find them?

d) Explain what happens to the idealised expanded high temperature feldspar structure (containing Na and K) when the temperature falls. What microscopic texture do you observe in alkali feldspar as a result of this structural change?

e) Silica (SiO_2) has a number of polymorphs that exist at different pressure and temperature conditions. Describe the different phases that exist, giving their names and approximate P/T conditions. (hint: you can also sketch a phase diagram to show this information)