UNIVERSITY OF JOHANNESBURG

FACULTY	: Science
DEPARTMENT	: Geology
CAMPUS	: APK
MODULE	: GLG1A02/GLG2A10 IGNEOUS ROCKS
SEMESTER	: First
EXAM	: **Special Exam**

DATE	: 2019	**SESSION**	: 08:00-11:00
ASSESSOR(S)	: PROF M. Elburg		
MODERATOR	: PROF H. Mouri		
DURATION	: 3 HOURS	**MARKS**	: 100

NUMBER OF PAGES: 7 PAGES

INSTRUCTIONS:

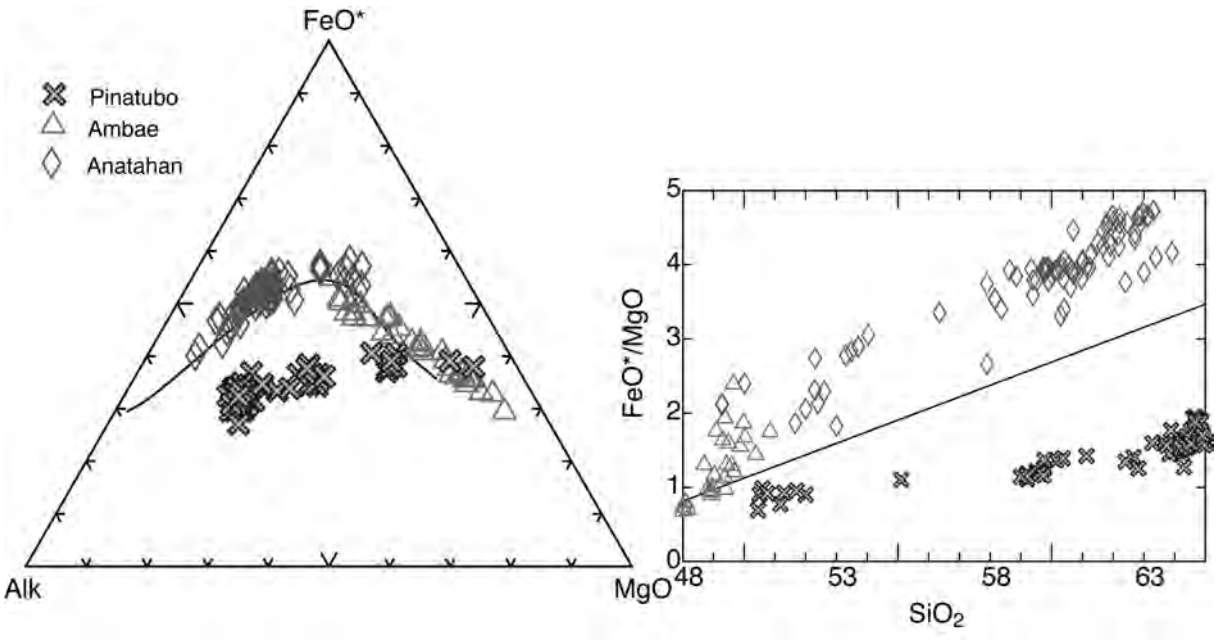
1. Answer ALL THE QUESTIONS.
2. Number your answers clearly
3. Explain yourself adequately when asked to do so, and write legibly, in correct English.
4. Enter your student number on the question sheet

QUESTION 1 (5+5 = 10 marks)

a. Explain which melt would have the higher viscosity, if we compare them at the same temperature: a melt of albite, or a melt of nepheline? Albite has a higher ration of (Al+Si):Na, wherby the former are networkformers, and the latter a network modifier, than nepheline, and therefore albite has the higher viscosity.

b. What is the difference between a pyroclastic fall deposit and a pyroclastic flow deposit (=ignimbrite), in terms of the type of clasts, clast sizes, clast size variation, and mode of formation? A pyroclastic fall is the material that rains from the sky during a volcanic eruption, and consists mainly of pumice and ash (or scoria, it if is a more mafic eruption) The clasts decrease in size with distance from the volcanic vent, but have a relatively homogeneous size distribution in any one spot. A pyroclastic fall consists of more varied material, also including lithics, and the have a more varied size distribution, although the bigger clasats are typically in the lower part of the deposit, whereas the pumice floats, and there is an ash layer on top (typical ignimbrite deposit). A pyroclastic flow is a high-speed, hot, dense cloud that slows over the ground, as a result of column collapse, dome collapse, lateral eruption, etc.

QUESTION 2 (2+2+4 = 8 marks)



The two diagrams above show data for three different volcanoes, Pinatubo, Ambae and Anatahan. The datasets for the two diagrams are of course the same.

a. In the left diagram what does 'Alk' stand for? Alkalis: Na2O+K2O

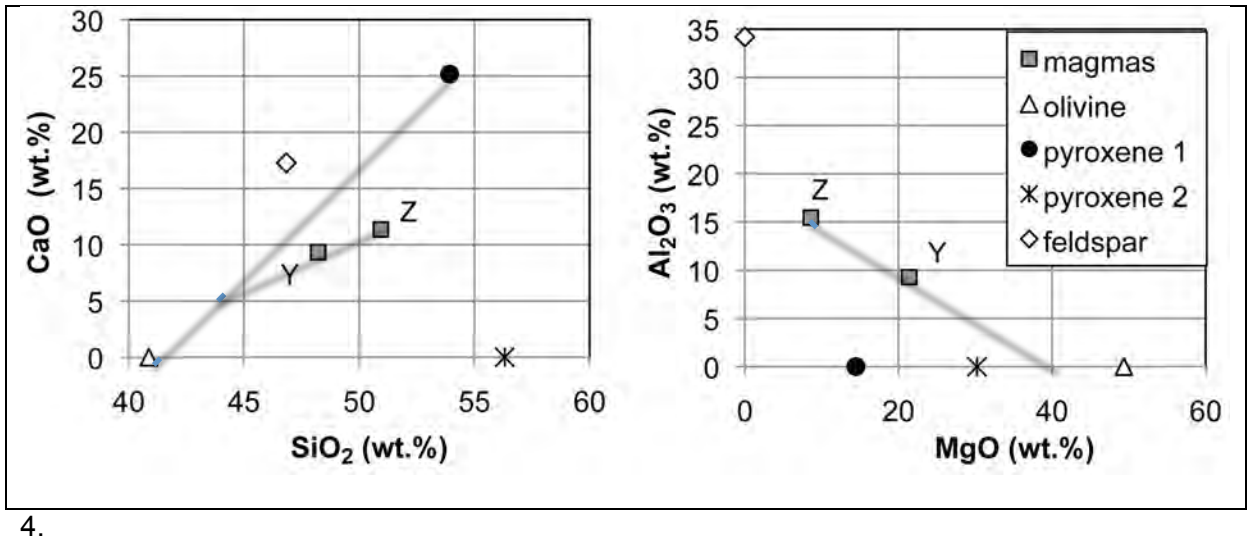
b. In the right diagram, what does the little star next to FeO mean? That all iron is reported as Fe^{2+}.

c. Discuss whether the magmas from these three volcanoes show calc-alkaline or tholeiitic differentiation trends. Pinatubo very CA, (no iron enrichment during differentiation, and straight to the alkalis corner in the AFM diagram); the other two marginally tholeiitic, with moderate iron enrichment during differentiation.

QUESTION 3 (8 marks)

A lava sample contains 15% plagioclase phenocrysts, and 85% glass. The glass that is in equilibrium with the plagioclase phenocrysts contains 200 ppm Sr. The plagioclase/melt distribution coefficient for Sr is 3. What is the Sr concentration of this lava sample? 0.85*200+0.15*600=260 ppm.

QUESTION 4 (2+4+2+2 = 10 marks)



4.

The two diagrams above show the composition for two magmas, and some minerals. Use these diagrams to answer the following questions.

A. The two magmas are related to each other by fractional crystallisation. Explain which one is the more evolved one, Y or Z. Z has lower MgO and higher SiO2, so it is the more evolved one.

B. Two minerals fractionate to produce the more evolved magma from the more primitive magma. Which two minerals, in which proportions? Ol75%, px1 25%.

C. There are two pyroxenes shown on the diagram. What is the most likely mineral name for the one with the lower MgO content? Diopside (clinopyroxene): contains significant CaO.

D. Is the feldspar that is shown on the diagram rich in anorthite, albite or orthoclase component? High calcium and aluminium: anorthite

QUESTION 5 (6*2 = 12 marks)

Give the most appropriate names for the intrusive rocks with the following minerals:

Sample	quartz	plagio-clase	microc line	sodalite	other	biotite	amphi-bole	augite	ortho-pyroxene	olivine
A		63						17	15	5
B		2	5	12	58 leucite	10		13		
C	20	50	8					12	10	
D			49	32	2 eudialyte	5	12			
E	6	14	71			9				
F								38	42	20

A: olivine gabbro
B: leucitolite
C: granodiorite
D: sodalite syenite
E: Quartz syenite
F: olivine websterite

QUESTION 6 (5*2 = 10 marks)

Fill in the blanks:

a. Dolerites often display an ophitic texture in thin section, whereby plagioclase is wholly enclosed by clinopyroxene.

b. A lamprophyre can be described as a mafic igneous rock, which is rich in potassium, and which often occurs as dykes. This rock type does not feature in either the QAPF or TAS classification.

c. When you look at a thin section of a komatiite under the microscope, you expect to see its characteristic spinifex texture.

d. Crystals that are shaped like a needle, are also called acicular.

e. A pumiceous texture is typical for a vesicular pyroclastic rock, which has a felsic composition, and a very high number of very small vesicles.

QUESTION 7 (6*2 = 12 marks)

	A	B
SiO_2	43.22	73.77
TiO_2	0.97	0.37
Al_2O_3	12.20	13.23
Fe_2O_3*	10.38	2.98
MnO	0.17	0.04
MgO	14.54	0.81
CaO	10.92	2.84
Na_2O	2.04	3.87
K_2O	4.76	2.03
P_2O_5	0.82	0.05
Quartz	0.00	35.14
Plagioclase	10.21	45.60
Orthoclase	0.00	12.06
Nepheline	9.40	0.00
Leucite	22.24	0.00
Diopside	18.77	0.88
Hypersthene	0.00	4.85
Olivine	28.50	0.00
Larnite	4.83	0.00
Ilmenite	1.86	0.70

The table to the left shows the geochemical analyses (in weight%) for two lavas, with their calculated normative minerals.

A. Explain whether all iron was assumed to be divalent when the normative mineralogy was calculated. No, both 2+ and 3+, as there is magnetite present.

B. What kind of basalt would lava A be, based on its position in the basalt tetrahedron? Alkali basalt because of the nepheline in the norm.

C. Do you think it is appropriate to also plot sample B in the basalt tetrahedron? Explain. No, it isn't a basalt.

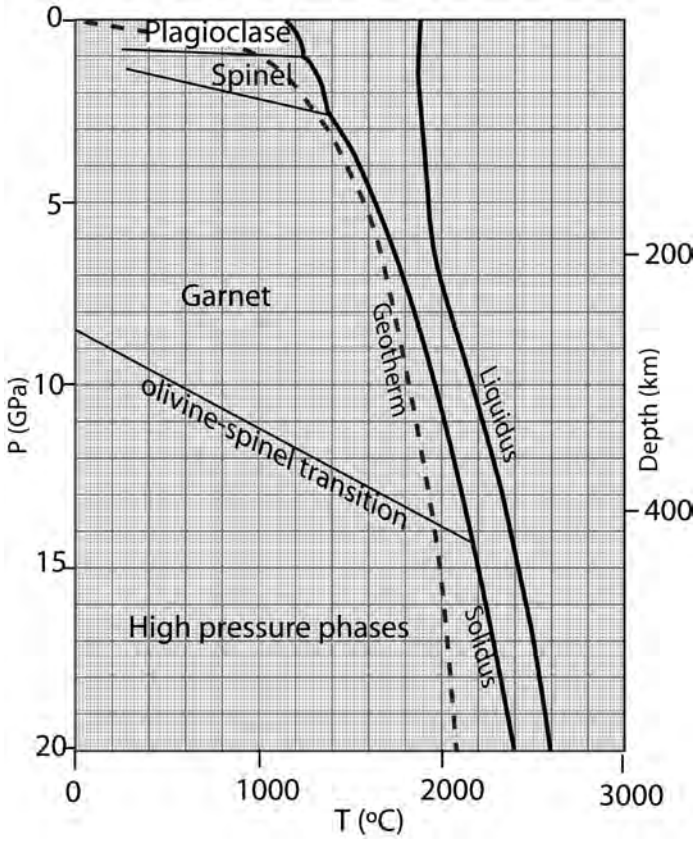
D. What are the names of these two samples based on the TAS diagram? basanite, rhyolite

E. What are the names of these two samples if we assume that they are intrusive rocks, and that the normative minerals represent the modal mineralogy of these samples? leucite gabbro, granodiorite

F. In what tectonic setting is lava A most likely to have been generated: mid-ocean ridge, oceanic island, or island arc? Explain. OI: ne-normative: deep melting (mantle plume).

Magnetite	2.28	0.65
Apatite	1.92	0.12

QUESTION 8 (4*3 = 12 marks)



The diagram to the left shows the solidus and liquidus for the mantle, the geotherm, and the stability fields for selected minerals.

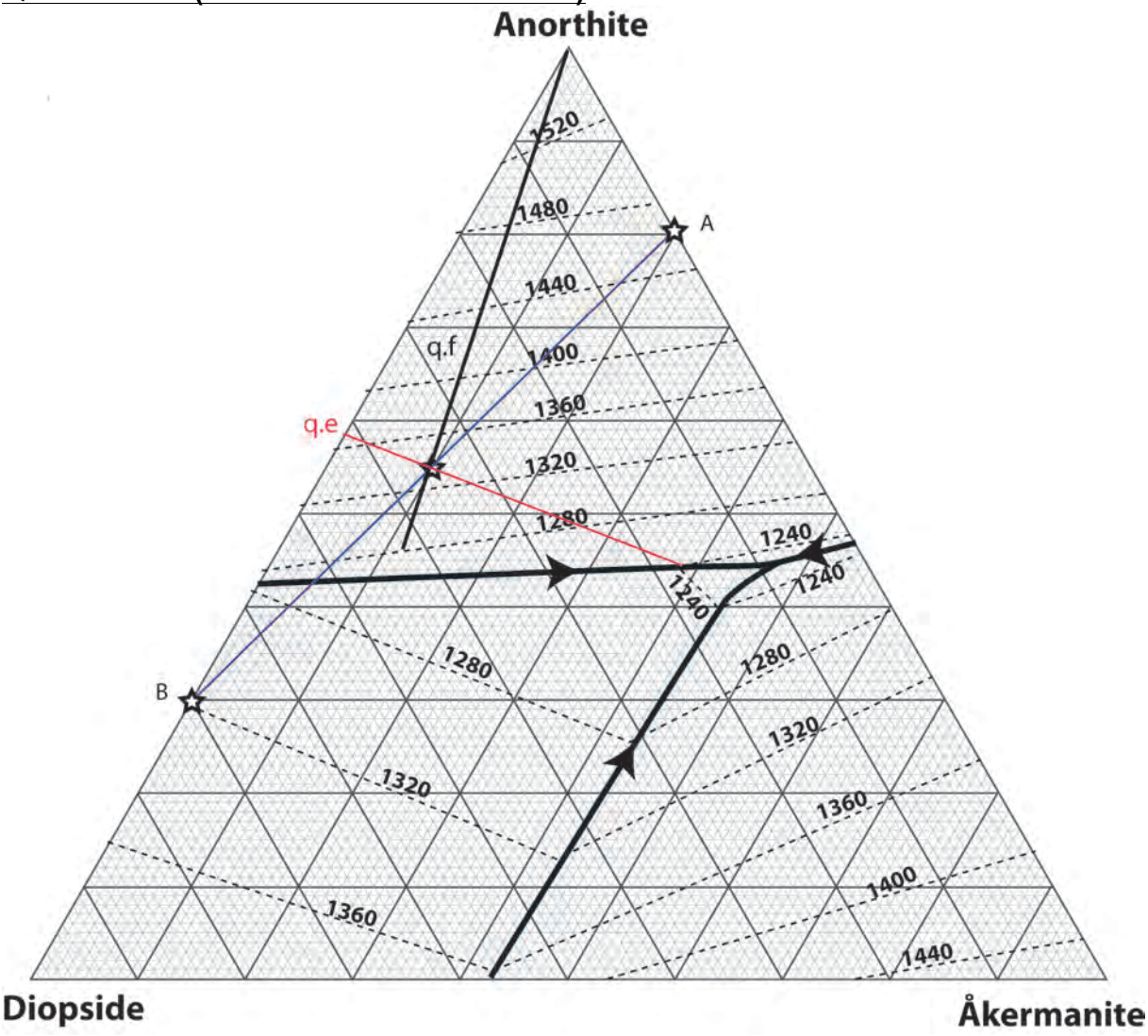
A. At what temperature does the mantle start melting at a pressure of 20 kbar? 1360˚C

B. Which aluminium-bearing phase is stable in the mantle at 1273 K and 5 GPa, and what is its mineral formula? Garnet, likely pyrope rich: $Mg_3Al_2Si_3O_{12}$

C. Is the mantle that lies on the geotherm at 4 GPa completely solid, partially molten or completely molten? Explain. Geotherm is everywhere below solidus, so also at 4 GPa: completely solid.

D. If the mantle ascends adiabatically from the geotherm at 4 GPa, will the percentage of melt increase, decrease or stay the same? Explain. It will remain solid until it gets to the solidus at ca. 3.3 GPa, and then it will start melting, with the melt percentage increasing as it ascends further.

QUESTION 9 (2+2+1+1+4+4+4=18 marks)



The diagram above gives the phase diagram for the ternary system diopside-anorthite-åkermanite at 1 atmosphere pressure. The mineral formula for åkermanite is $Ca_2MgSi_2O_7$. The thin lines with numbers are the isotherms (degrees C). The thicker lines are the boundaries to the primary phase fields.

a. We consider compositions A and B, plotted in the diagram above. How many grams of which minerals would we need to mix together to get ten grams of composition A, and ten grams of composition B? A: 2 g Åk, 8 g An; B: 3 g An, 7 g Di

b. At which temperatures would compositions A and B start melting? A: ca. 1235˚C; B: ca. 1275˚C

c. We now mix together the ten grams of solid A and B, and thereby obtain a mixture that we call C. Draw the composition of C in the diagram above.

d. At what temperature would composition C start melting? Ca. 1230 ˚C

e. Of which phases, and in which percentages does composition C consist at 1240 ˚C? 27%melt, 73 xtals of which 57%An and 43% Di, so 43% An, 30% Di

f. Of which phases, and in which percentages, does composition C consist at 1280 ˚C? 17%An, 83% melt

g. Of which phases, and in which percentages, does composition C consist at 1360 ˚C? 100% melt

Handy equations and other things:

$\Delta_{rx}G = \Delta_{rx}H - T\Delta_{rx}S$

$\frac{dG}{dP} = V$

$\frac{dG}{dT} = -S$

$\Delta G_{rx,\ T',\ P'} = \Delta G_{rx,\ T\mathit{ref},\ P\mathit{ref}} + \Delta V_{rx}\ (P' - P_{\mathit{ref}}) - \Delta S_{rx}\ (T' - T_{\mathit{ref}})$

$d\Delta G = \Delta V dP - \Delta S dT$

$P+F=C+2$

$D_i^{a/b}$ (or $Kd_i^{a/b}$) $= C_i^a / C_i^b$

$\frac{C_l}{C_0} = \frac{1}{F+D-FD}$

$\frac{C_l}{C_0} = F^{(D-1)}$