



UNIVERSITY OF GHANA

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**FACULTY OF ENGINEERING SCIENCES
BSc. (ENG) MATERIALS SCIENCE AND ENGINEERING
END OF SECOND SEMESTER EXAMINATION: 2013/2014
MTEN 314: Ceramic Processing Principles (3 Credits)**

Answer Question ONE (1) and ANY OTHER TWO (2) Questions

Time Allowed: 3 hours

Q1. Ekem Ceramics Limited wants to produce a body for electrical insulators. The company has access to several different types of raw materials preparation (eg. traditional, hydrothermal, and sol-gel); and also, it can invest in various processing techniques (such as, extruding, jiggering or slip casting, drying, sintering or firing).

a) From the triaxial diagram (Figure 1) provided:

- i) select a body composition from the range of electrical insulators
- ii) add 30 % plastic clay to improve the plasticity of the body
- iii) Use the following raw materials: Nvelenu kaolin, Agbozume silica, Egyaa feldspar, and Esiana plastic clay
- iv) These raw materials must add up to 100 %. *[10 marks]*

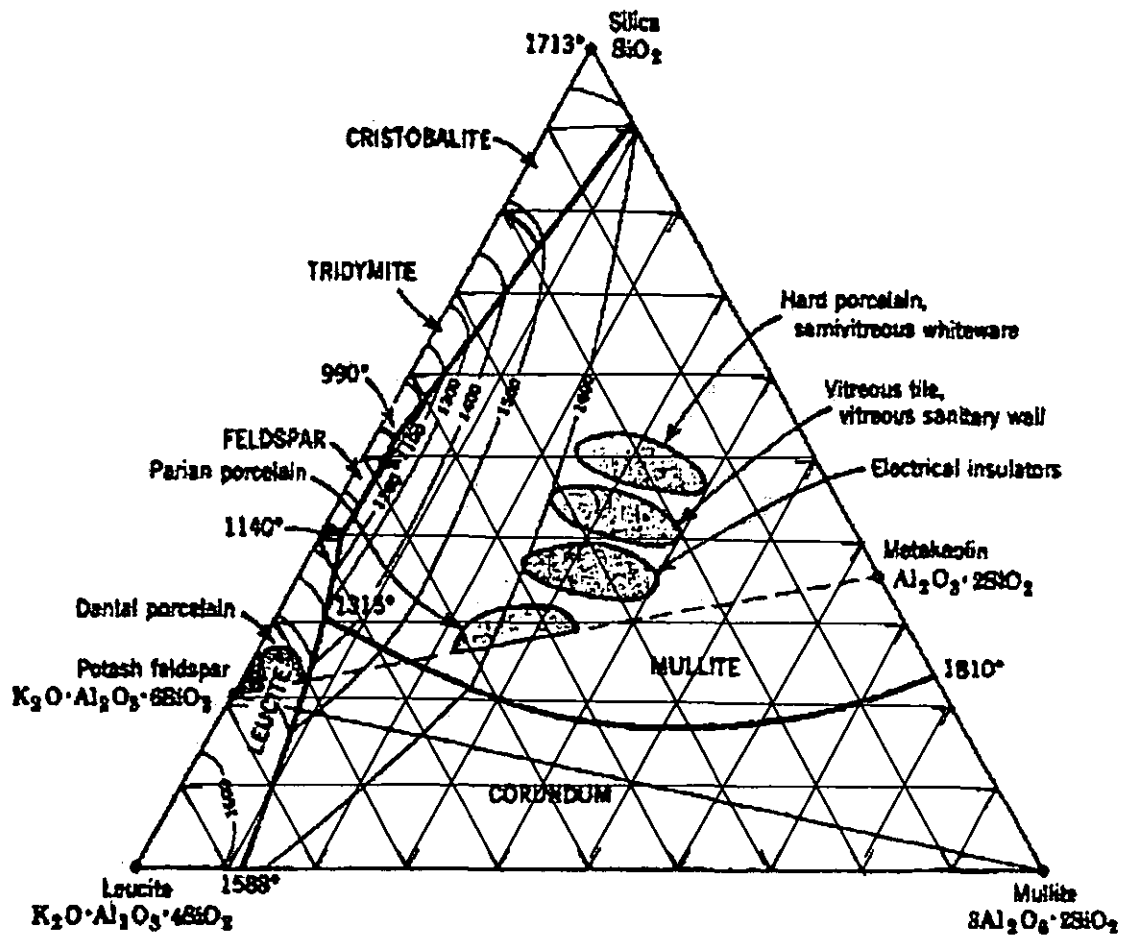


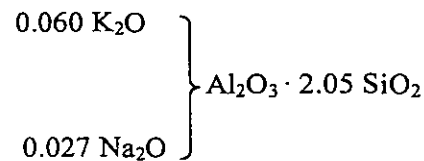
Fig. 1: Feldspar-kaolin-silica Triaxial diagram

(Showing leucite-mullite-cristobalite portion of the K₂O-Al₂O₃-SiO₂ phase diagram)

b) Using a flow chart, explain the type of raw materials preparation and processing techniques that you would suggest for manufacturing the electrical insulators. Your explanation must include (i) the diffusion mechanisms involved in the sintering and (ii) the characteristics of the sintered ceramic. [20 marks]

c) What is the molecular formula of your body given that the molecular formulae of the ingredients are reported as follows:

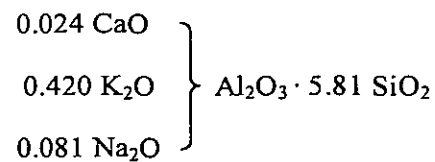
Esiama plastic clay:



Nvelenu kaolin: $\text{Al}_2\text{O}_3 \cdot 1.85 \text{ SiO}_2$

Agbozume silica: SiO_2

Egyaa feldspar:



The “Loss on Ignition” of Esiama plastic clay is 12 %; and that of Nvelenu kaolin is 13.5 %.

The molecular weights of the raw materials involved are given as follows (Table 1):

Table 1: Molecular Weights of the Raw Materials

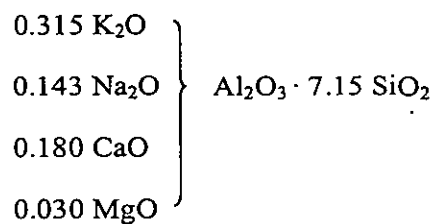
Material	Molecular Weight
Esiama clay	254.0
Nvelenu kaolin	254.0
Agbozume silica	60.2
Egyaa feldspar	544.8

[15 marks]

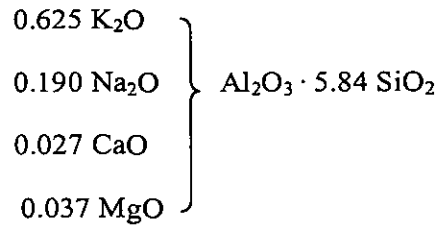
d) Ekem Ceramics Limited has also requested that the Ofankor feldspar of the body for its dinnerware must be replaced with Hebron feldspar. The dinnerware body composition is given as:

:	Esiama plastic clay	20 %
	Nvelenu kaolin	10 %
	Agbozume sand	40 %
	Ofankor feldspar	30 %

It is desired to replace the Ofankor feldspar, which has the following formula:



with Hebron feldspar, which has the following formula:



What will be the new dinnerware body composition, assuming that the formula of the Esiama clay and Nvelenu kaolin are given as: $\text{Al}_2\text{O}_3 \cdot 2 \text{ SiO}_2$ and that of the Agbozume sand is given as SiO_2 ?

Table 2 shows the molecular weights of the raw materials involved.

Table 2: Molecular Weights of the Raw Materials

Material	Molecular Weight
Esiama plastic clay	254
Nvelenu kaolin	254
Agbozume sand	60.2
Ofankor feldspar	526
Hebron feldspar	549

[15 Marks]

Q2. "Ceramic engineering involves the use of inorganic, nonmetallic materials to develop materials that support products and systems that help to improve our well-being". Discuss this with respect to rocks, minerals, and ceramic processing.

[20 marks]

Q3. At the structural examination level, it is seen that almost all whitewares undergo solid state substitution and cross-linking of layer into three (3) dimensional networks. Discuss the development of the whitewares from forming temperature to temperatures above 1200°C, with emphasis on five possible phenomena observed. Use illustrations where necessary. [20 marks]

Q4. "Underlying many of the properties found in ceramics are the strong primary bonds that hold the atoms together and form the ceramic material". Discuss this statement in detail. [20 marks]