



UNIVERSITY OF GHANA

(All rights reserved)

**BSC. MATERIALS SCIENCE AND ENGINEERING
END OF FIRST SEMESTER EXAMINATIONS: 2015/2016
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING**

MTEN 403: REFRACTORIES (2 Credits)

TIME ALLOWED: TWO (2) HOURS

SECTION A: Multiple Choice

(20 marks)

ANSWER ALL QUESTIONS IN THIS SECTION

1. Which of the following materials has the least linear thermal expansion coefficient?
 - (a) Silica
 - (b) Periclase
 - (c) Vitreous silica
 - (d) 80 % Al_2O_3 .
2. Which of the following materials has the highest refractoriness?
 - (a) SiO_2
 - (b) Fireclay
 - (c) Al_2O_3
 - (d) Fire brick.
3. Which is the odd one?
 - (a) MgO
 - (b) SiO_2
 - (c) CaO
 - (d) doloma.
4. A material with high thermal conductivity has
 - (a) high susceptibility to thermal shock
 - (b) high thermal shock resistance
 - (c) low thermal shock resistance
 - (d) steep thermal gradient.
5. Low bulk density of a refractory material means
 - (a) low porosity
 - (b) high porosity
 - (c) high refractoriness

- (d) low refractoriness
6. Which of the following is not a polymorph of SiO_2 ?
- (a) corundum
 - (b) quartz
 - (c) tridymite
 - (d) cristobalite.
7. Which of the following is a sluggish polymorphic transformation?
- (a) displacive transformation
 - (b) reconstructive transformation
 - (c) slow kinetic transformation
 - (d) low temperature transformation.
8. Which of the following industries is the largest refractory materials consumer?
- (a) cement and lime;
 - (b) ceramic;
 - (c) steel;
 - (d) ~~prochemical.~~ *petrochemical*
9. Which is the odd refractory material in the following?
- (a) MgO
 - (b) SiO_2
 - (c) firebrick
 - (d) mullite.
10. Which of the following is not likely to be a phase in a well sintered fire clay brick?
- (a) mullite
 - (b) cristobalite
 - (c) tridymite
 - (d) glass.

SECTION B: ANSWER ALL QUESTIONS IN THIS SECTIONS

- 1.
- (a) Arrange the following from lowest to highest refractoriness: alumina, silica, and mullite.
 - (b) Mention six applications of silica refractories
 - (c) Name and discuss two silica refractory raw materials in terms of purity, density and application.
 - (d) Briefly describe the manufacture, properties and applications of shaped fused silica products.

(30 marks)

2.

- (a) Explain the term “dead burnt” as it applies to basic refractories.
- (b) Contrast macrocrystalline and cryptocrystalline magnesite in terms of their purity, reactivity and suitability to produce high density magnesia refractories.
- (c) Describe the magnesia carbon paradox and state the mechanism by which $\text{MgO}+\text{C}$ refractories resist corrosion and penetration by steel making slag.
- (d) State and describe four applications of magnesia refractories.
- (e) As the Engineer with responsibility to select an MgO refractory material for an application which requires contact with slag. You are presented with MgO from two suppliers A and B with apparent porosities 12 % and 20 % respectively. If the price of material is not a selection criteria, which of the two MgO materials will you select for better performance? Briefly explain your answer.

(30 marks)

3.

- (a) Contrast the single-pass and double pass processes as they relate to the production of doloma from dolomite.
- (b) Describe the advantage of doloma bricks over alumina bricks in the desulfurization of aluminium killed steel.
- (c) Describe the mechanism by which doloma grains spall upon hydration.
- (d) By what mechanisms do doloma nozzles prevent the clogging by alumina particles in alumina killed steels?

(20 marks)

SECTION C: BONUS QUESTIONS (OPTIONAL). ANSWER FOR EXTRA MARKS

4. Use Figure 1 to answer the following questions. Attach Figure 1 to your answer booklet as appropriate.

- (a) Locate the refractory material of composition 95 wt% MgO , 3 wt% SiO_2 and 2 wt% Al_2O_3 within the ternary phase diagram. **(5 marks)**
- (b) What composition triangle does the refractory composition in (a) above belong and what are the stable phases within this refractory material after equilibrium sintering? **(5 marks)**
- (c) This refractory material is in equilibrium with a slag of composition 80 wt% SiO_2 and 20 wt% Al_2O_3 . What are the potential corrosion products? **(10 marks)**

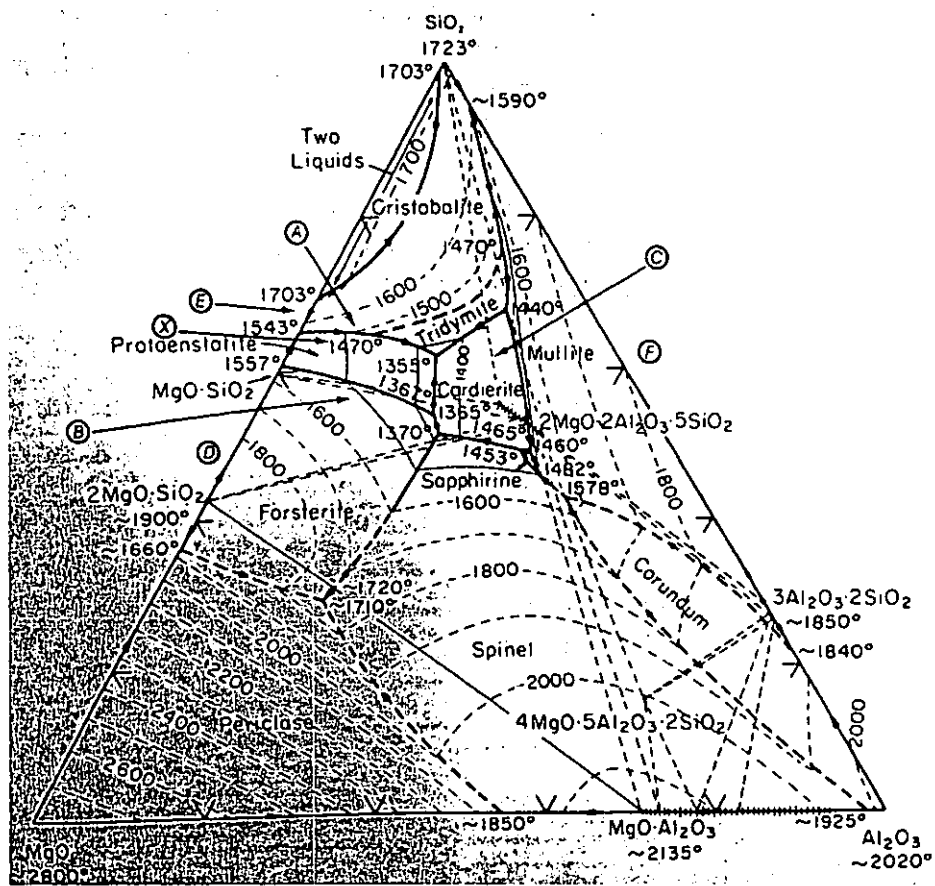


Figure 1

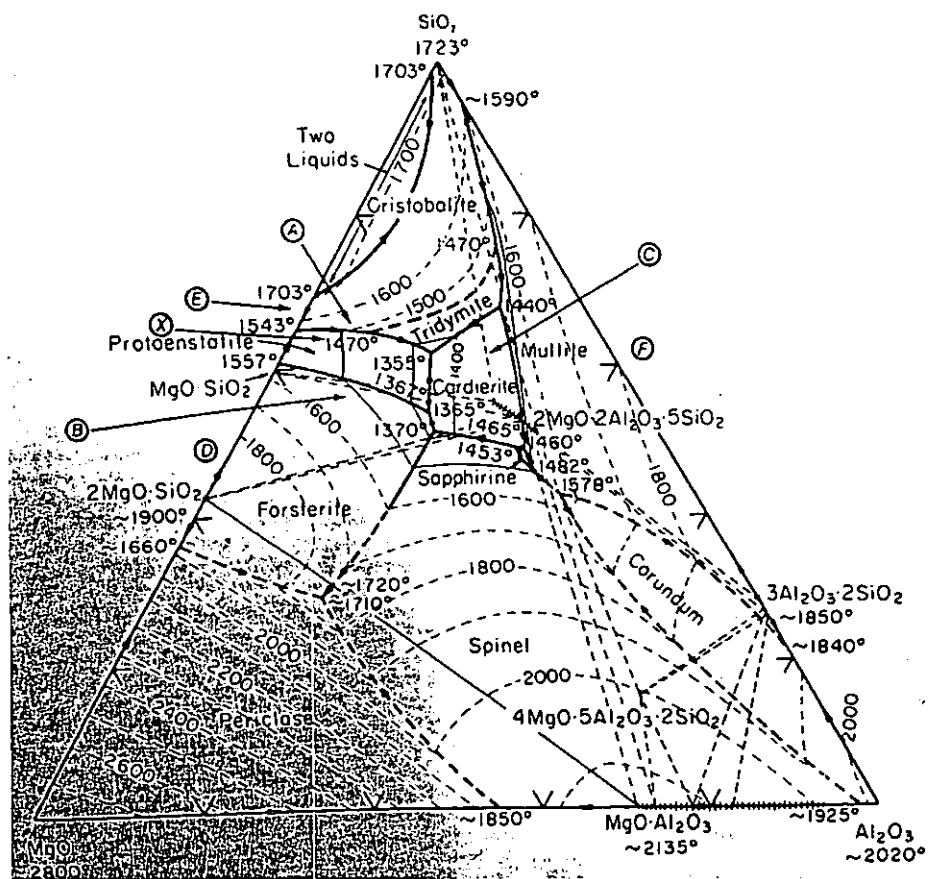


Figure 1