UNIVERSITY OF GHANA

BSC. MATERIALS SCIENCE AND ENGINEERING
END OF FIRST SEMESTER EXAMINATIONS: 2016/2017
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MTEN 409: GLASSES, CEMENTS AND CONCRETES (2 Credits)

TIME ALLOWED: ***TWO (2) HOURS***

ANSWER ALL QUESTIONS.

1.

a. Describe the glass transition temperature, Tg using specific volume vs temperature plots for crystalline and glasses.
b. With the aid of appropriate diagram describe the effect of cooling rate on the density of glasses.
c. Contrast the crystallite and random-network models glass structure.
d. Name the Zachariasen rules to be satisfied by an oxide in order to form a glass.
e. Describe the three types of cations commonly found in oxide glass including their functions. Give two examples of each.
f. By what mechanism does a network former modifier function?
g. State two requirements for the formation of noncrystalline ceramic from a melt instead of a crystalline ceramic to be possible.
h. Using Table 1 (page 2) as a guide, why are SiO_2 and B_2O_3 good glass formers but NaCl and $CaSiO_3$ are not good glass formers?

30 Marks

2.

a. For each of the following types of glass, state typical composition, properties and two applications. (i) fused silica glass; (ii) soda lime silica glass and (iii) Pyrex.
b. For soda-lime-silica glass, describe the function of each of the three components.
c. For silica melt containing 5 % soda, state the composition of the final liquid to solidify under equilibrium conditions and at what temperature. Use Figure 1 (page 2).
d. What are glass ceramics? Compare the general characteristics of glass with glass ceramics.
e. Describe the process for making glass ceramics with the aid of appropriate diagram.

30 Marks

Table 1 Factors Affecting Glass-Forming Ability

Composition	T_{mp}(°C)	$\Delta H_f/T_{mp}$ (cal/mole/°K)	$(1/\eta)_{mp}$ (poise^{-1})	$(\Delta H_f/T_{mp}) \times (1/\eta)_{mp}$	Comments
B_2O_3	450	7.3	2×10^{-5}	1.5×10^{-4}	Good glass former
SiO_2	1713	1.1	1×10^{-6}	1.1×10^{-6}	Good glass former
$Na_2Si_2O_5$	874	7.4	5×10^{-4}	3.7×10^{-3}	Good glass former
Na_2SiO_3	1088	9.2	5×10^{-3}	4.5×10^{-2}	Poor glass former
$CaSiO_3$	1544	7.4	10^{-1}	0.74	Very difficult to form as glass
NaCl	800.5	6.9	50	345	Not a glass former

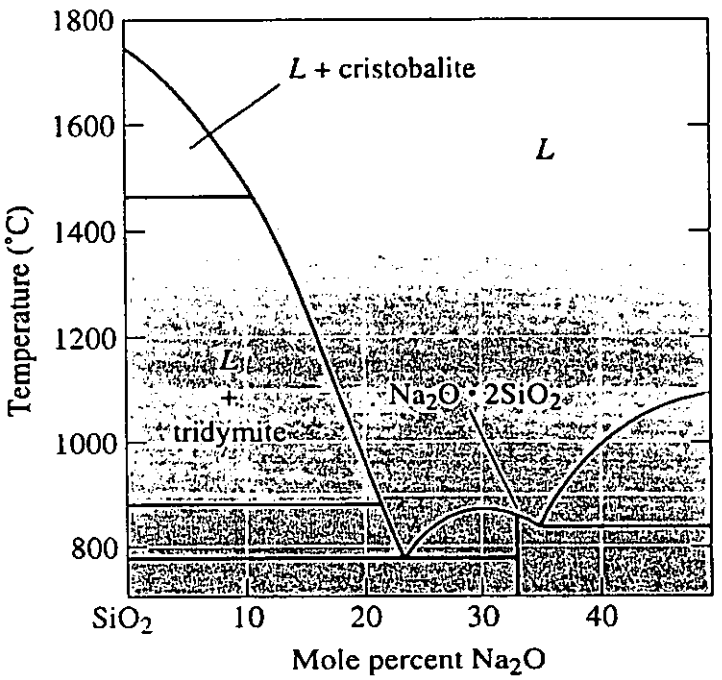

Figure 1 SiO_2-Na_2O phase diagram. Additions of soda (Na_2O) to silica dramatically reduce the melting temperature of silica by forming eutectics.

3.

a. What are the components of Portland cement and typical compositions?
b. Name and describe the functions of the typical phases in Portland cement.
c. What are the typical phase compositions of and the characteristics of Type I and Type III?
d. Describe the role of gypsum in Portland cement.

20 Marks

4.

a. What are the components and typical batch composition of concretes?
b. Name and describe three (3) pozzolans and their effect on the properties of concrete.
c. Describe the manufacture of the following concretes
    i. Autoclaved Aerated Concrete (AAC)
    ii. Prestressed concrete

20 Marks