



# UNIVERSITY OF GHANA

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**BSC. MATERIALS SCIENCE AND ENGINEERING**

**END OF FIRST SEMESTER EXAMINATIONS: 2015/2016**

**DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING**

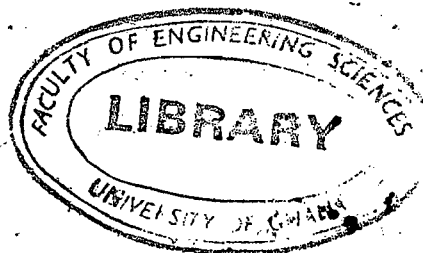
**MTEN 307: PHASE EQUILIBRIA OF MATERIALS (2 Credits)**

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

**ANSWER ALL QUESTIONS.**

1.
  - a. Classify the following systems as monovariant, divariant, or invariant. Explain your answers
    - i. Alpha quartz in equilibrium with beta quartz at the transition temperature.
    - ii. Monoclinic zirconia at room temperature.
    - iii. Ice in equilibrium with its vapor.
  - b.
    - i. Define the Clausius – Clapeyron relationship and state its relevance in evaluating phase equilibria in one component systems.
    - ii. For a sublimation phase equilibrium, show that
$$P = e^{\left(-\frac{\Delta H_{sub}}{RT}\right)}$$
Where  $P$  is the pressure on the system,  $T$  is temperature of the system,  $R$  is the gas constant and  $\Delta H_{sub}$  is the enthalpy of sublimation.
  - c. From Figure 1 (Page 2), indicate whether the following statement is true or false.
    - i.  $S_1$  is denser than  $S_2$  and the transformation from  $S_1 \rightarrow S_2$  is exothermic.
    - ii.  $S_1$  is denser than  $S_2$  and the transformation from  $S_1 \rightarrow S_2$  is endothermic.
    - iii.  $S_1$  is less dense than  $S_2$  and the transformation from  $S_1 \rightarrow S_2$  is exothermic.
    - iv.  $S_1$  is less dense than  $S_2$  and the transformation from  $S_1 \rightarrow S_2$  is exothermic.

**25 Marks**



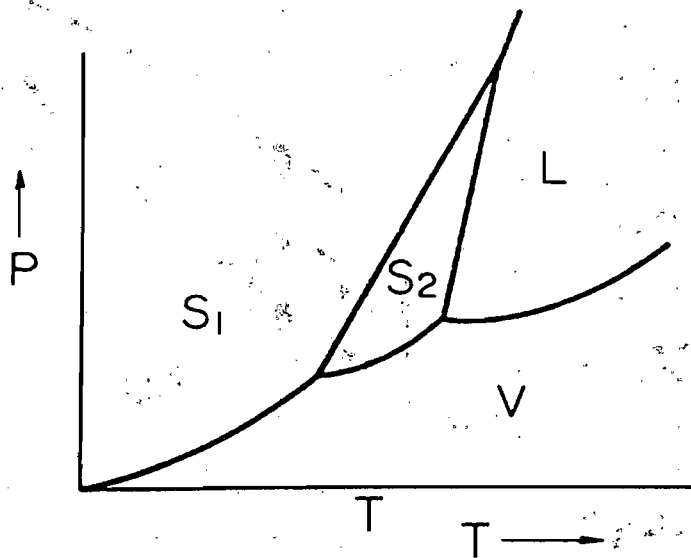


Figure 1

2. Use Figure 2 (Page 3), to answer the following questions.
  - a. What are the melting points of NiO and MgO?
  - b. What can you say about the two oxides in terms of valence, crystals structure and cationic radii?
  - c. Conduct an isoplethal study of a melt with composition 60 mol% NiO and 40 mol% MgO considering temperatures 2430 °C, 2350 °C and 2250 °C for your calculations. Present your results in a tabulated format.
  - d. Sketch the microstructure of the system at each of the three temperatures indicated in 2(c) above.

25 Marks

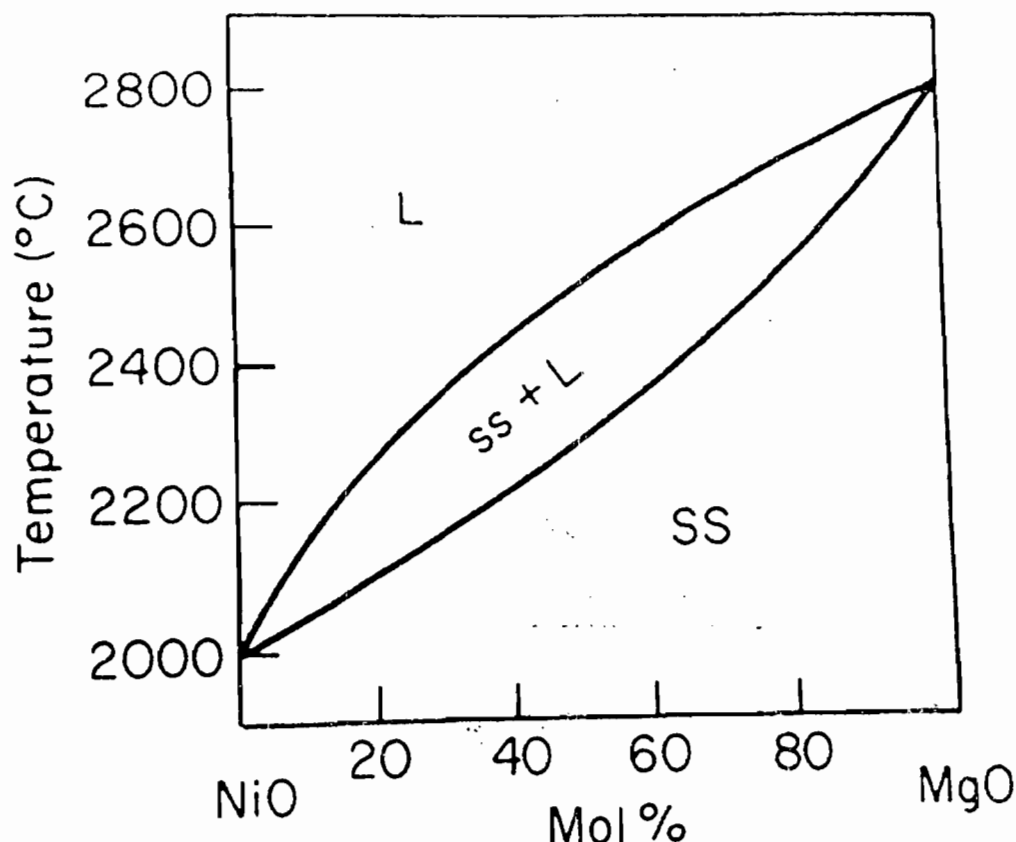


Figure 2

3. Use Figure 3 (Page 4) to answer the following questions.
- Label all the areas indicated from I – X.
  - Identify and name all the invariant equilibria, indicate the temperature at which they occur and write the respective reaction that occurs. Follow the tabular format example in Table 1 (Page 4).
  - Is the binary compound  $\text{NiO} \cdot \text{V}_2\text{O}_5$  congruently or incongruently melting? Explain your answer.

25 Marks



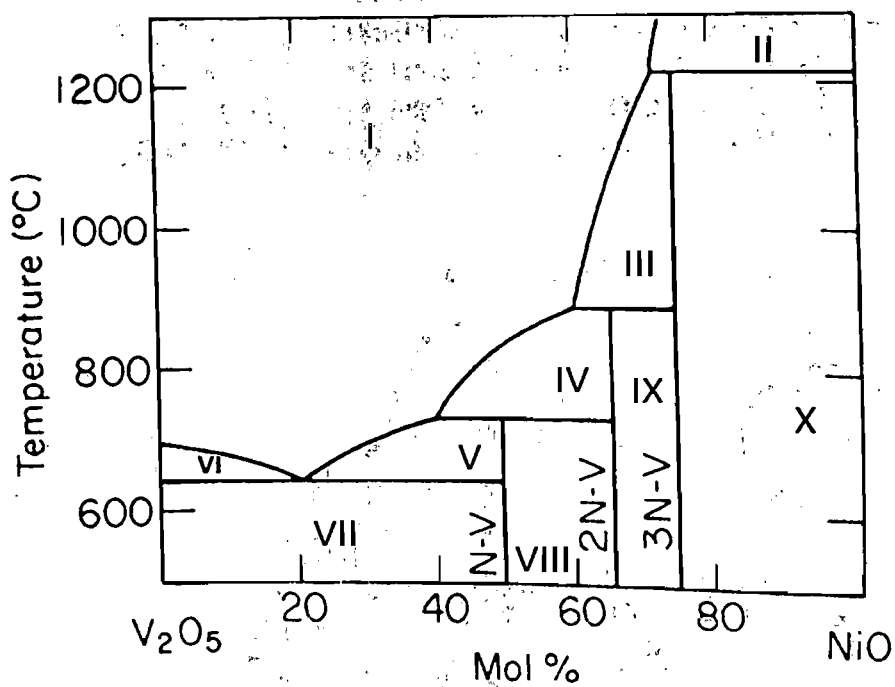
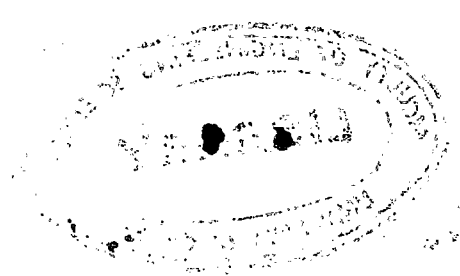


Figure 3

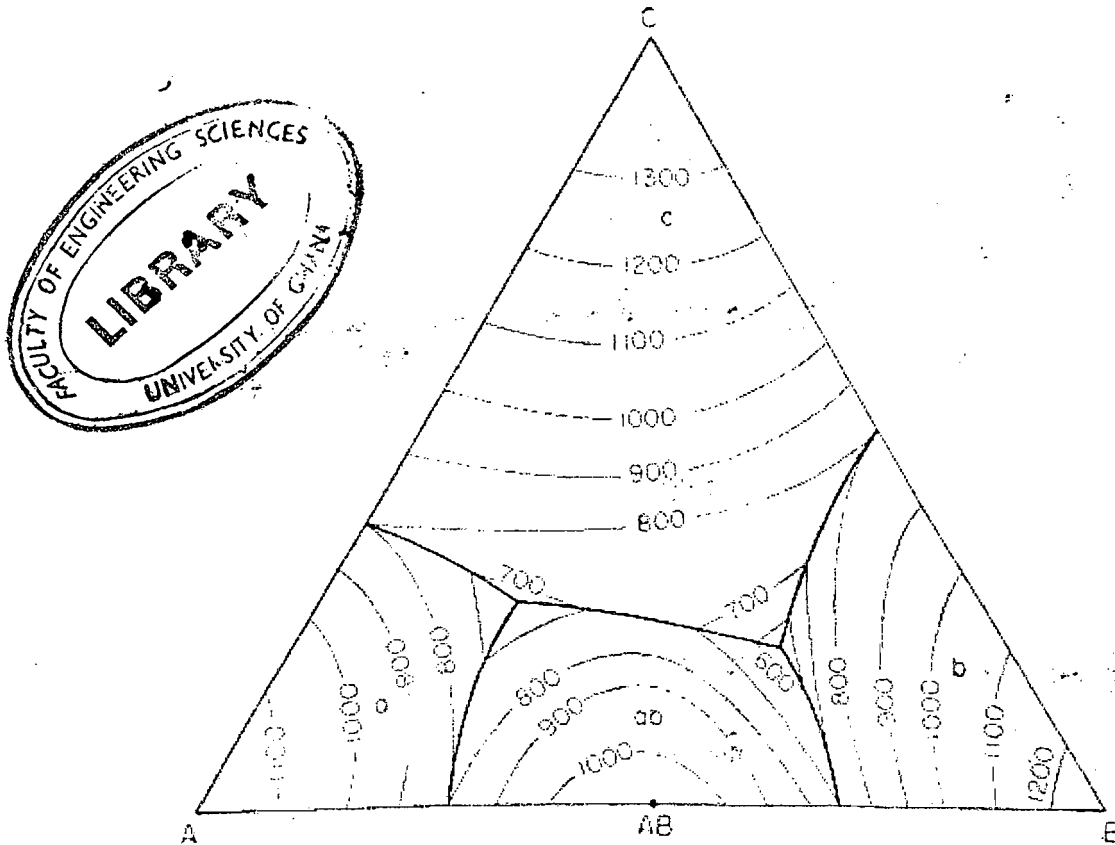
Table 1

Invariant Point Name	Approx. Temperature °C	Invariant reaction
Melting point	Not indicated on diagram	$NiO \rightarrow \text{Liquid}$



4. Use Figure 4 to answer the following questions. Use and attach the extra print out of this figure where necessary.
- Construct Alkemade lines and indicate slopes of boundary lines.
  - Write the two eutectic invariant reactions.
  - Make a sketch of the isothermal sections at 700 °C and label.
  - For a melt of composition A=30%, B= 5% and C = 65%
    - What is the composition of the final crystals?
    - What is the composition of the final liquid to solidify?

**25 Marks**



**Figure 4**

INDEX NUMBER: .....

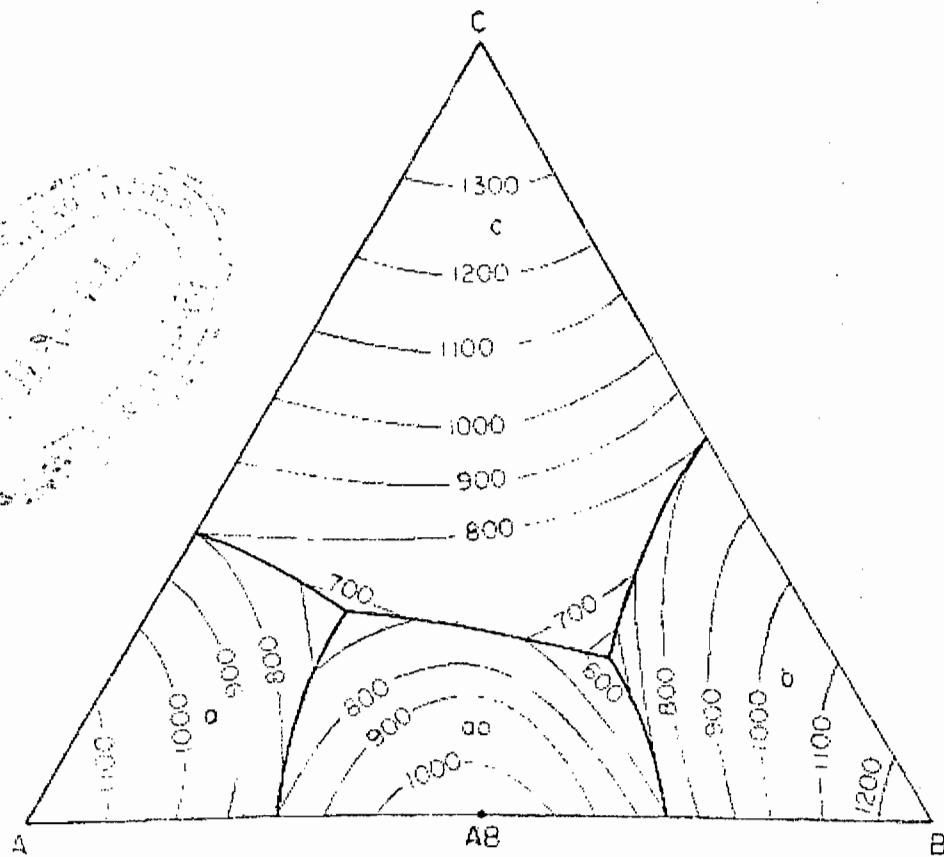
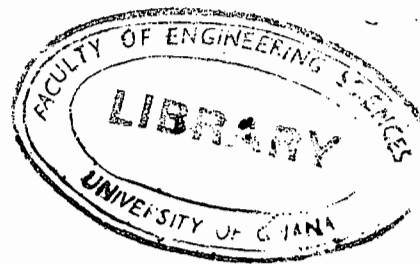


Figure 4



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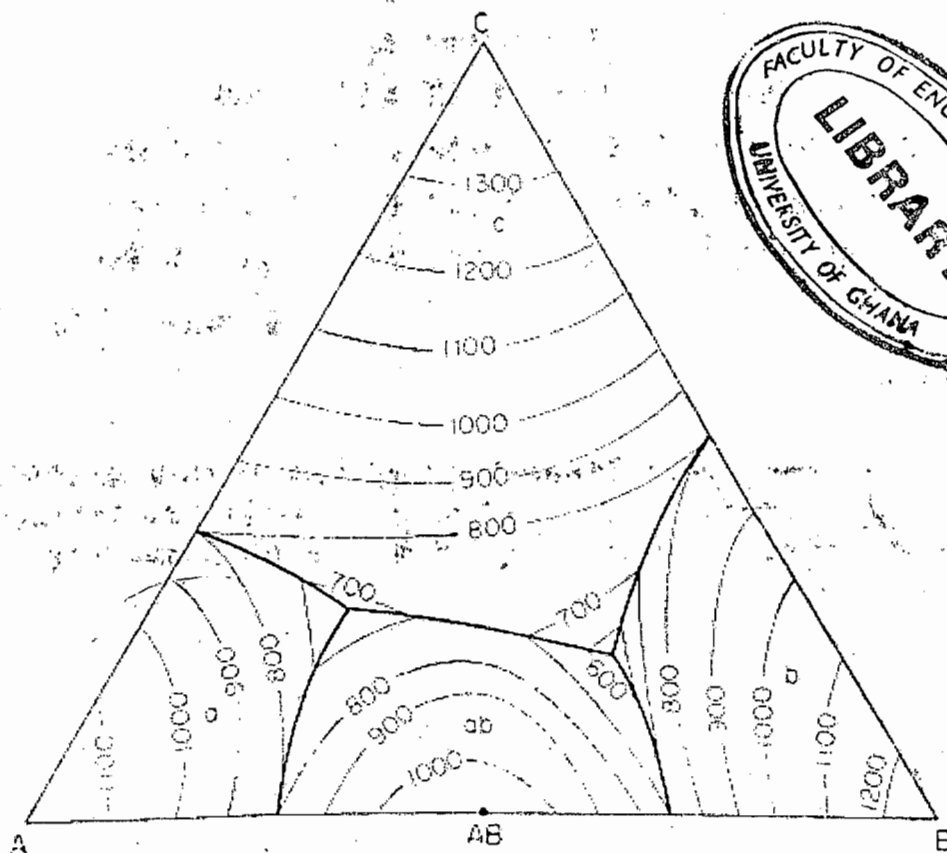


Figure 4