UNIVERSITY OF GHANA

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

MTEN 307: PHASE EQUILIBRIA OF MATERIALS (2 Credits)

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

ANSWER ALL QUESTIONS.

1.

a. Using the Clausius – Clapeyron relationship, derive an expression for the pressure on the system (P) in terms of the temperature of the system for an evaporation phase equilibrium. Take the heat of vaporization to be ΔH_{vap}.

b. The following phases are known to exist in a system at constant pressure:
Cordierite ($2MgO{\cdot}2Al_2O_3{\cdot}5SiO_2$)
Mullite ($3Al_2O_3{\cdot}2SiO_2$)
Forsterite ($2MgO{\cdot}SiO_2$)
Protoenstatite ($MgO{\cdot}SiO_2$)
Periclase (MgO)
   i. What are the components of the system?
   ii. Could all of the above-listed phases coexist at equilibrium? Explain your answer.

c. Classify the following systems as monovariant, divariant, or invariant. Explain your answers
   i. Beta quartz in equilibrium with beta tridymite at the transition temperature.
   ii. Graphite at room temperature.
   iii. Ice in equilibrium with its vapor and liquid water.
   iv. Liquid phase in a binary system

d. From Figure 1 (Page 2), indicate whether the following statement is true or false.
   i. L is denser than S_2.

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ii. S_1 is denser than S_2 and the transformation from $S_1 \rightarrow S_2$ is endothermic.
iii. L is less dense than S_2
iv. V is more dense than L.

30 Marks

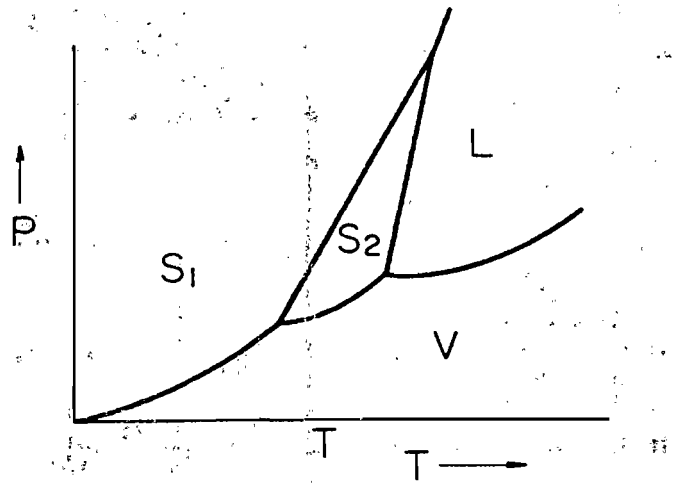

Figure 1

2. Use Figure 2 (Page 3), to answer the following questions.
   a. What name would you give to describe the binary system in Figure 2?
   b. Under what conditions is such a system possible?
   c. What are the melting points of copper and nickel?
   d. Conduct an isoplethal study of a melt with composition 20 wt% Ni considering only the temperatures at which the equilibrium phase(s) change(s) for your calculations. Present your results in a tabulated format.
   e. Sketch the microstructure of the system at each of the temperatures indicated in 2(d) above.

25 Marks

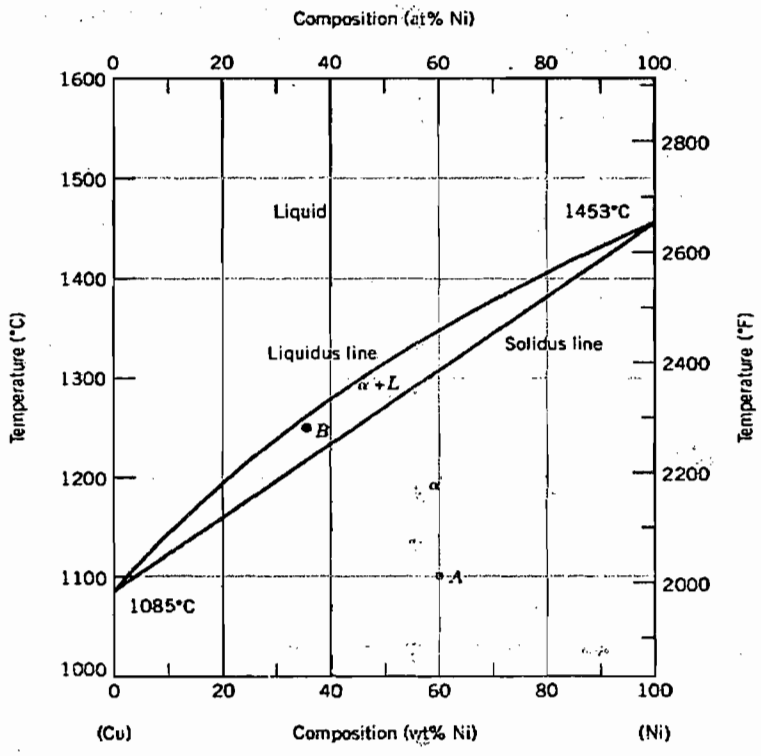

Figure 2

3. Construct the binary phase diagram which represents the following conditions in the system A-B:
   i. Component A melts at 1850 °C.
   ii. Component B melts at 1700 °C.
   iii. Compound A_4B melts incongruently at 1500 °C.
   iv. Compound AB melts congruently at 1600 °C.
   v. A eutectic is formed between A4B and AB at 1400 °C.
   vi. A eutectic is formed between AB and B at 1450 °C

   15 Marks

4. Use Figure 4 to answer the following questions. Use and attach the extra print out of this figure where necessary.
   a. Construct Alkemade lines and indicate slopes of boundary lines.
   b. What are the two compatibility triangles in the system?
   c. Write and name the respective invariant reactions at points E and D.
   d. Make a sketch of the isothermal sections at 600 °C and label.
   e. For a melt of composition A=20%, B= 15% and C = 65%

i. What crystalline phase will be first to form upon cooling?
ii. What is the composition of the final crystals?
iii. What is the composition of the final liquid to solidify?

30 Marks

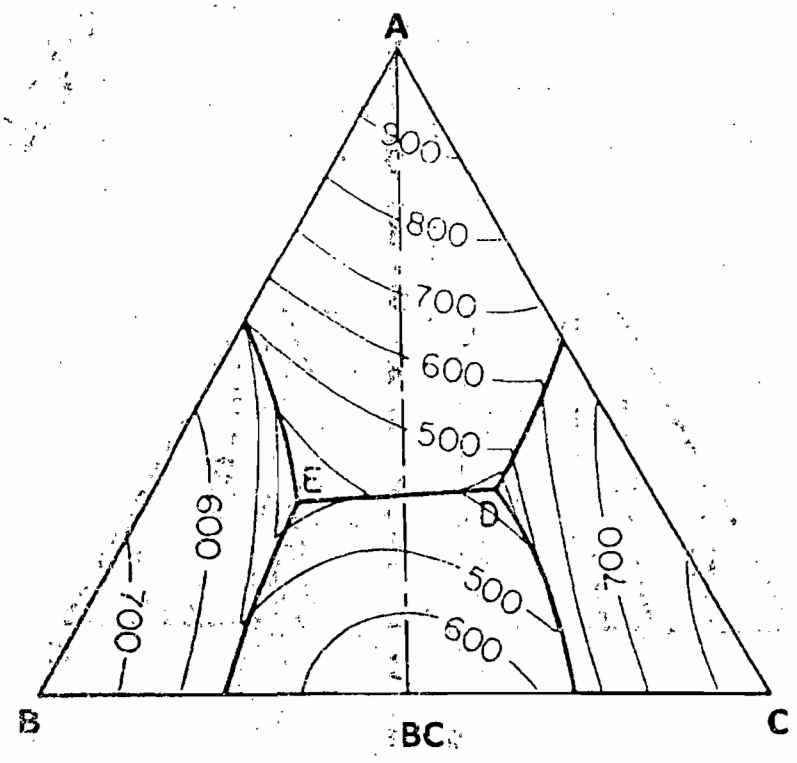

Figure 3

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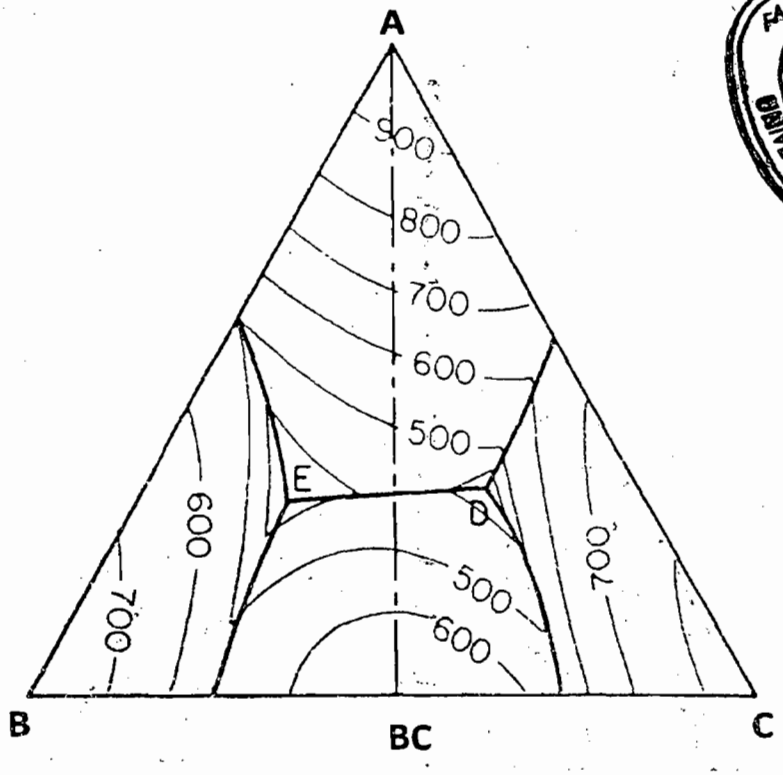

Figure 3

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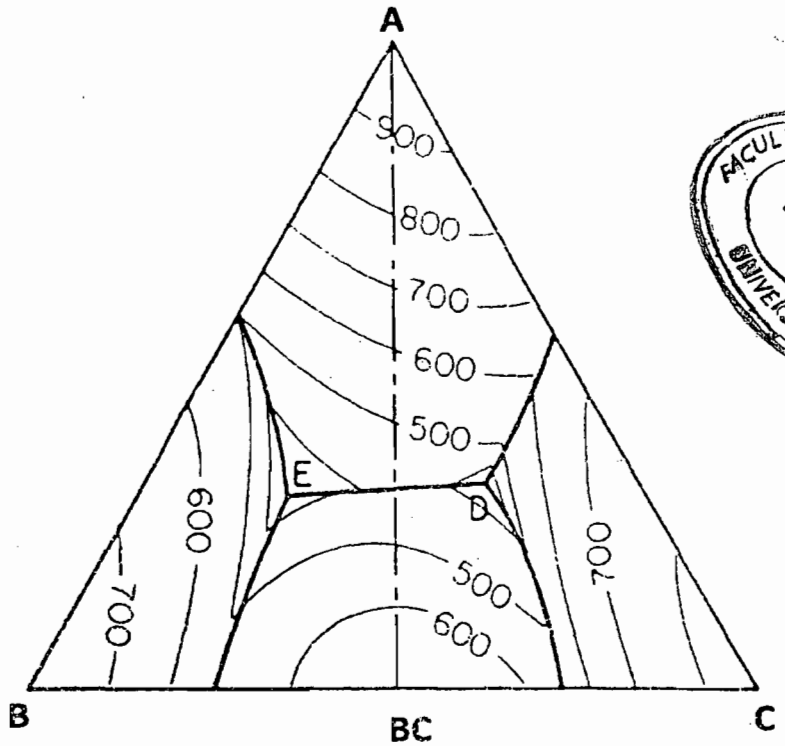

Figure 3