UNIVERSITY OF GHANA

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BSC. MATERIALS SCIENCE AND ENGINEERING
END OF FIRST SEMESTER EXAMINATIONS: 2018/2019
SCHOOL OF ENGINEERING SCIENCES
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEEINRG

MTEN 307: PHASE EQUILIBRIA OF MATERIALS (2 Credits)

INSTRUCTIONS:
ANSWER ALL QUESTIONS.

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

1.

a.

i. For an evaporation phase equilibrium on a one component phase diagram, show that

$$P = P_o e^{(-\frac{\Delta H_{vap}}{RT})}$$

Where P is the pressure on the system, T is temperature of the system, R is the gas constant and ΔH_{vap} is the heat of vaporization.

ii. Determine the heat of vaporization of water using Figure 1 on Page 2 for the water system. *NB: 760 mmHg = 1 atm = 101.3 kPa*

b. From Figure 2 (Page 2), indicate whether the following statement is true or false.

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

25 Marks

33

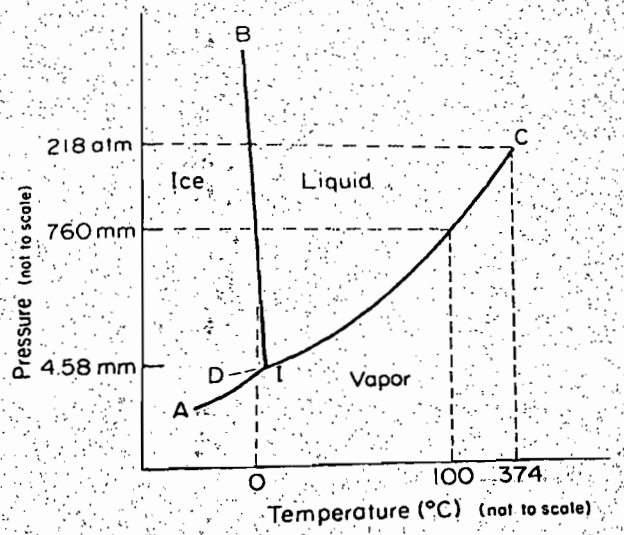

Figure 1 The Water System

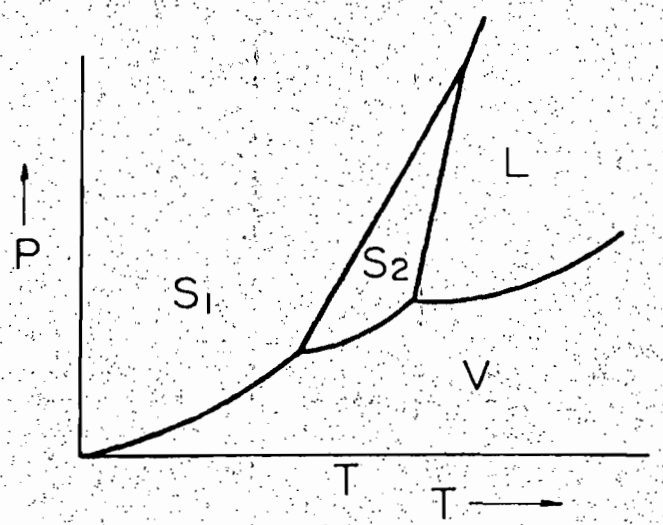

Figure 2

2.

a. For the binary system A – B, component A melts at a higher temperature than B. The system forms a simple binary eutectic diagram. Sketch and label the phase diagram for the A – B system.

b. Using Figure 3 (Page 3), answer the following questions.

   i. Identify all the invariant points and write out the relevant invariant reactions. Present your answer in a table format with one column for temperature, another for composition and the other for the invariant reaction.

   ii. Mg_2Pb is an intermediate compound, describe its melting behaviour.

   iii. Conduct an isoplethal analysis for a molten alloy containing 10 wt% Pb and sketch the equilibrium microstructure of the resulting alloy.

c. With the aid of an appropriate reaction, define an incongruently melting compound.

25 Marks

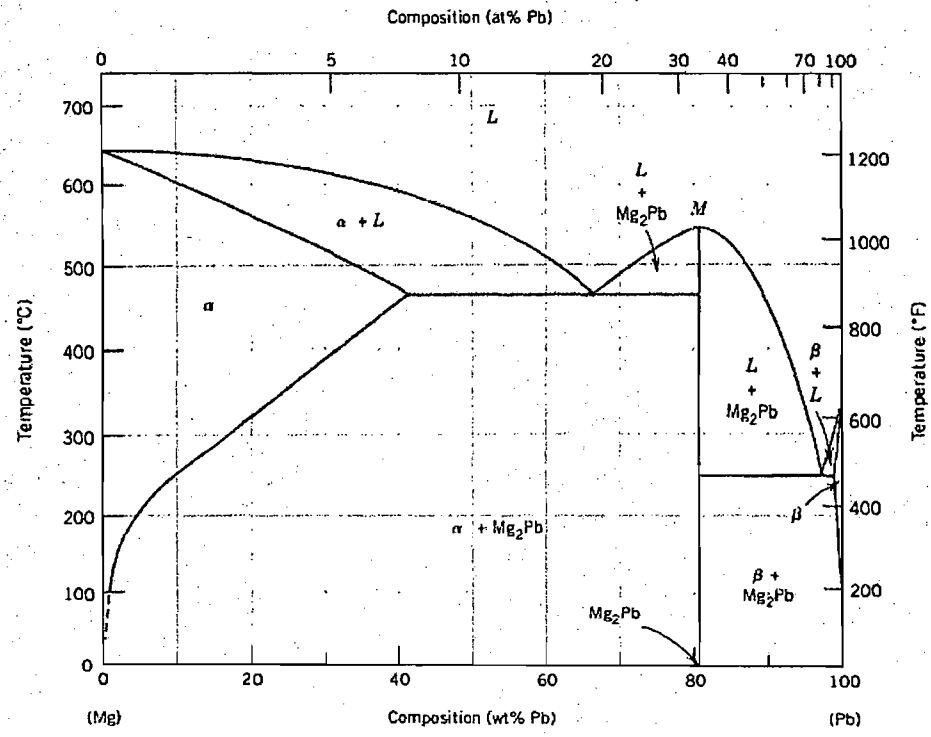

Figure 3

3. Use Figure 4 to answer the following questions. Use and attach the extra print out of this figure where necessary.
   a. Indicate the two compatibility triangles in the system and identify the temperatures and compositions of their invariant points? Tabulate your answer with a column for composition triangle, another for temperature of invariant point and the last for composition of invariant point.
   b. Write and name the respective ternary invariant reactions in the system.
   c. Make a sketch of, and label the isothermal sections at 700 °C.
   d. For a material of composition A=20%, B= 45% and C = 35%, at 700 °C, determine the equilibrium phases and quantify their relative amounts.
   e. A melt has composition that is located at the intersection of the Alkemade line C – AB with its boundary line. Upon solidification of this melt, what will be the final crystals and how much of each will be found in the microstructure?
   f. For a melt of composition A=40%, B= 30% and C = 30%
      i. What crystalline phase will be the first to form upon cooling?
      ii. What is the phase composition of the final crystals?
      iii. What is the composition of the final liquid to solidify?

50 Marks

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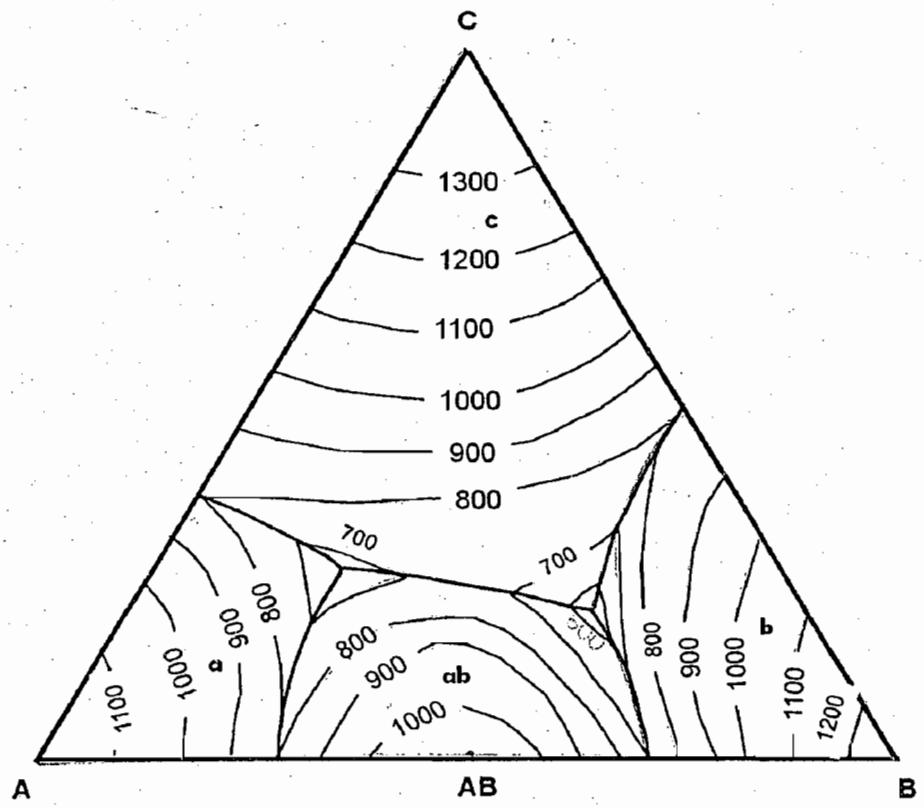

Figure 4

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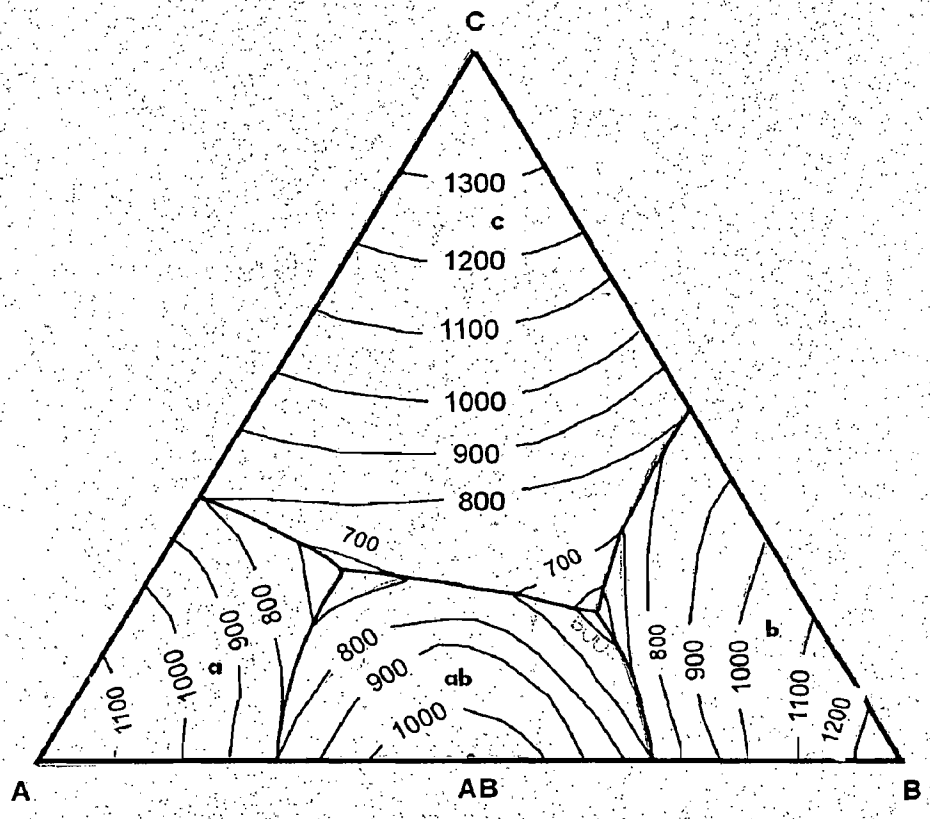

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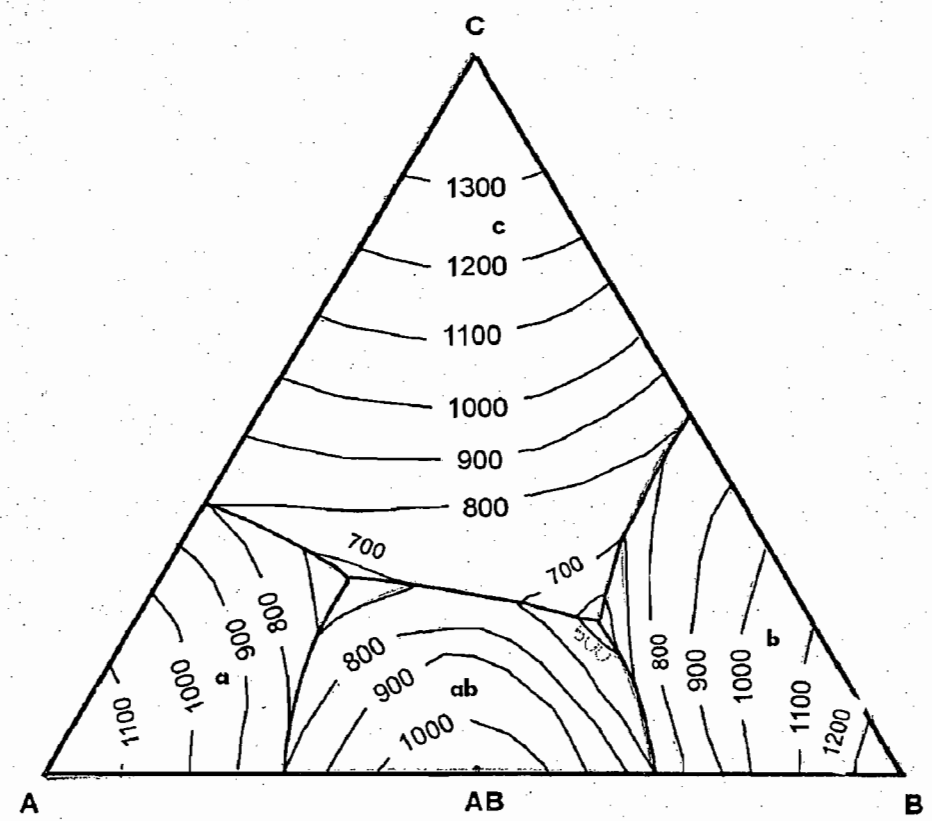

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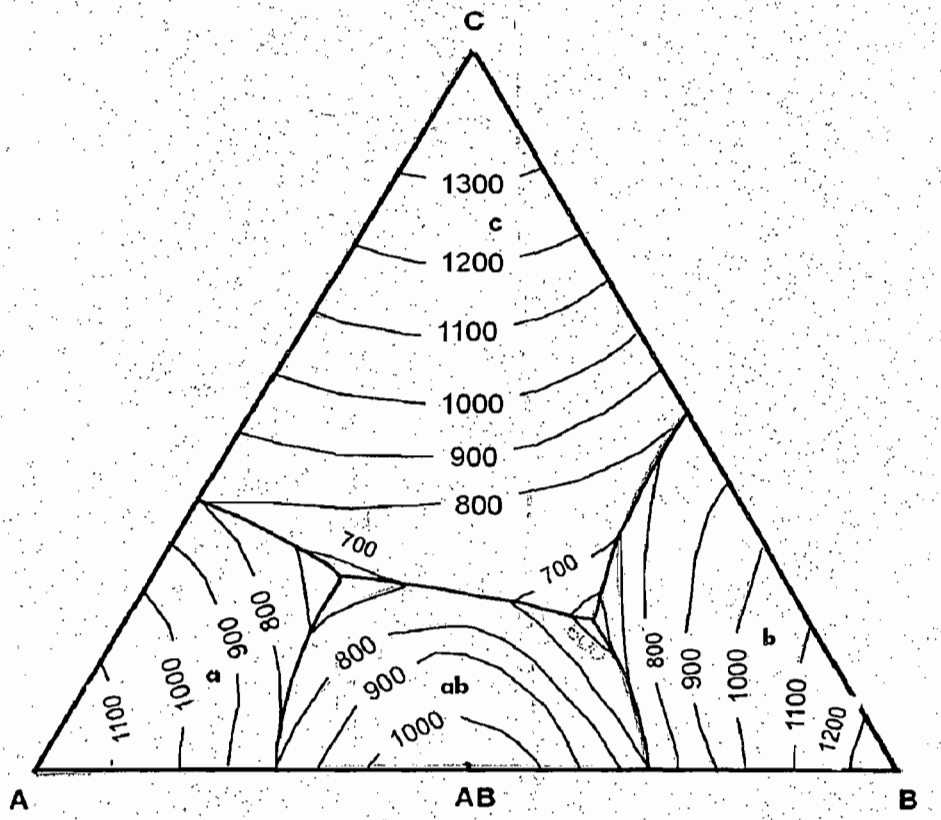

Figure 4