UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2004/2005

October 2004

EBB 512 - Phase Diagram and Phase Equilibria

Time : 3 hours

Please ensure that this paper consists of ELEVEN printed pages before you proceed with the examination.

This paper contains SEVEN questions.

Answer any FIVE questions. If a candidate answer more than five questions, only the first five answered will be examined and awarded marks.

Answer to any question must start on a new page.

All questions answered in English.

1. [a] For the temperature 2000°C, use the Be-W binary diagram (Fig. 1) to sketch the Gibbs free energy curves as a function of at %W needed to make up the phase diagram at this temperature. Be sure to note the important composition points on your graph.

Based on the phase diagram can you deduce about the elements W and Be relative to one another? Explain your reasoning.

(50 marks)

Be-W Phase Diagram

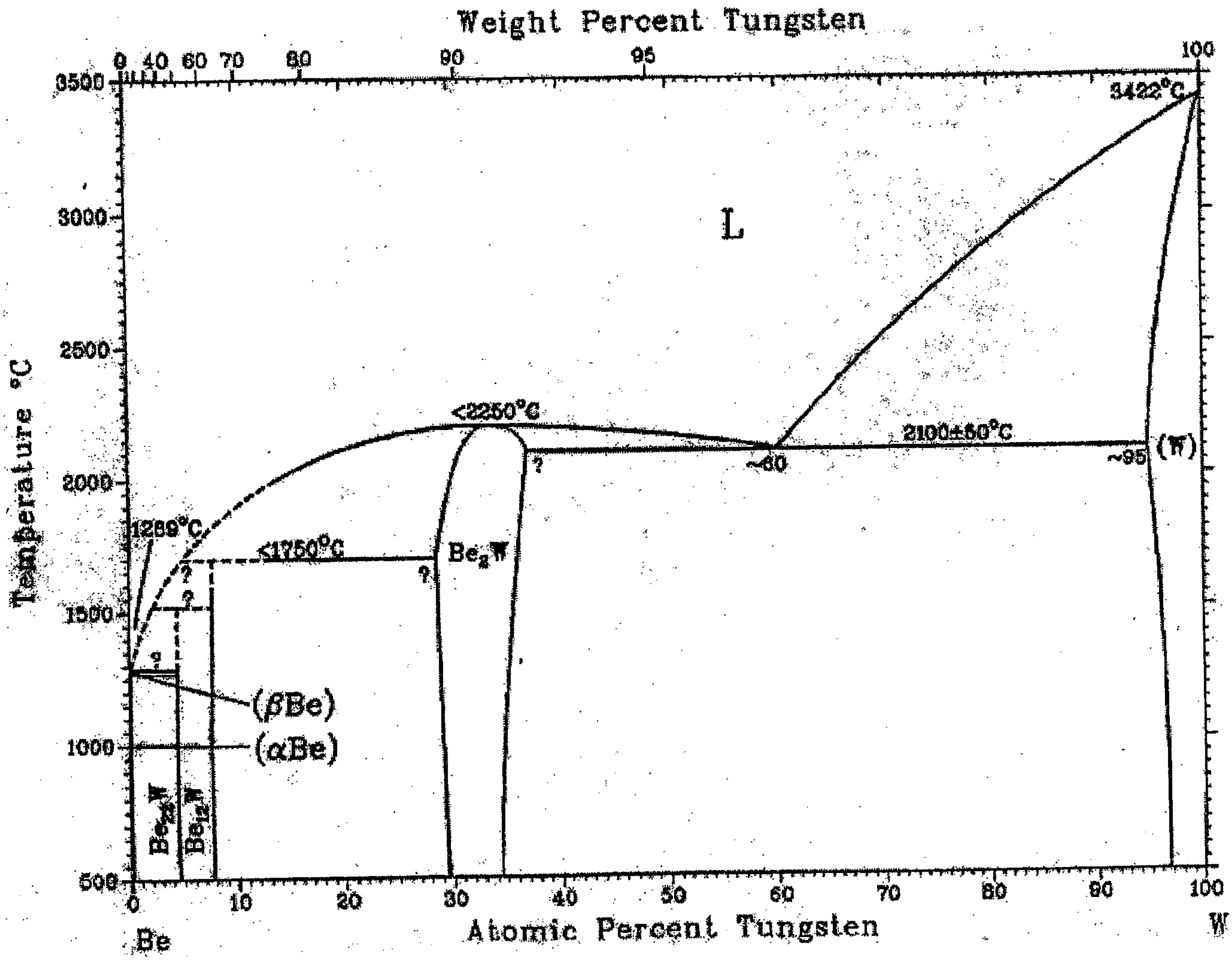

Figure 1

[b] We want to construct a binary phase diagram for the Cu-Nb system. Cu crystallizes as FCC, and Nb as BCC. To determine the phase diagram, we will need to calculate one free energy curve for each separate phase possible in this system.

(i) What is the SMALLEST NUMBER of free energy curves we will need to calculate?

(ii) Given your answer from part (i), how many G°, the Gibbs free energy values would we need to determine from thermodynamic data?

(iii) Would you expect the binary phase diagram to show significant solubility in the solid phase(s)? Why?

(40 marks)

[c] An experimenter has reported that a new phase ε was found to coexist in equilibrium with β, γ and δ phases at a particular set of conditions. What is your opinion about this report? (Fig. 2)

(10 marks)

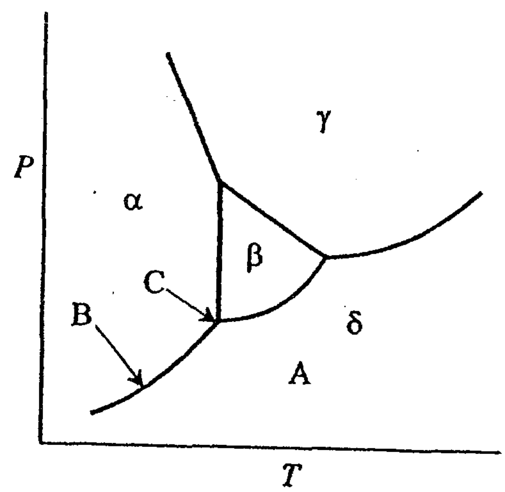

Figure 2

2. Refer Figure 3 for the following questions.

(a) Determine if there are any intermetallic compounds present? Are they stoichiometric or non-stoichiometric? Determine the formula for each compound.

(30 marks)

(b) Identify the three-phase reactions by writing down the temperature, the reaction in equation form, the composition of each phase in the reaction and the name of the reaction.

(30 marks)

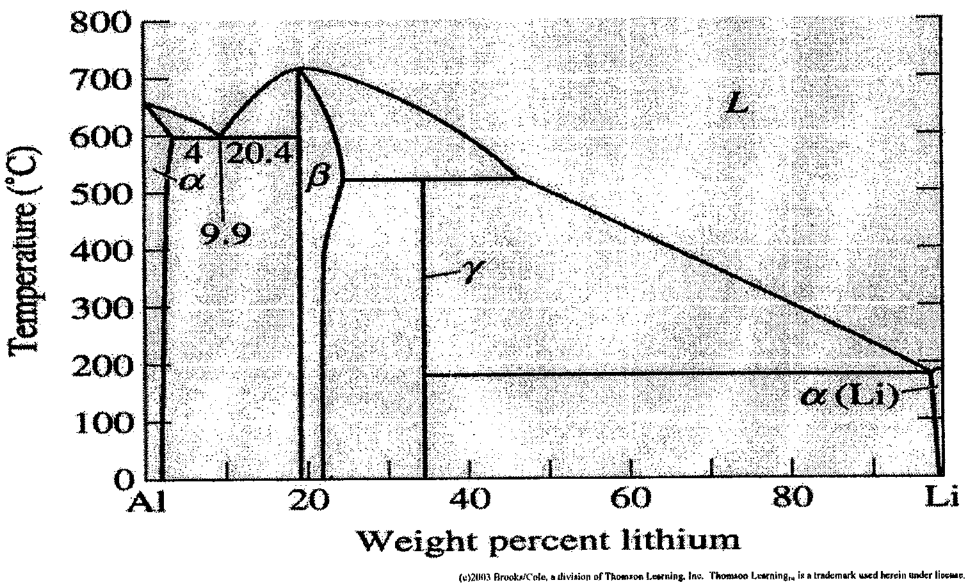

Figure 3 - The aluminum-lithium phase diagram

(c) How many grams of MgO must be added to 1 kg of NiO to produce a ceramic that has a solidus temperatures of 2200°C. Refer Figure 4.

(40 marks)

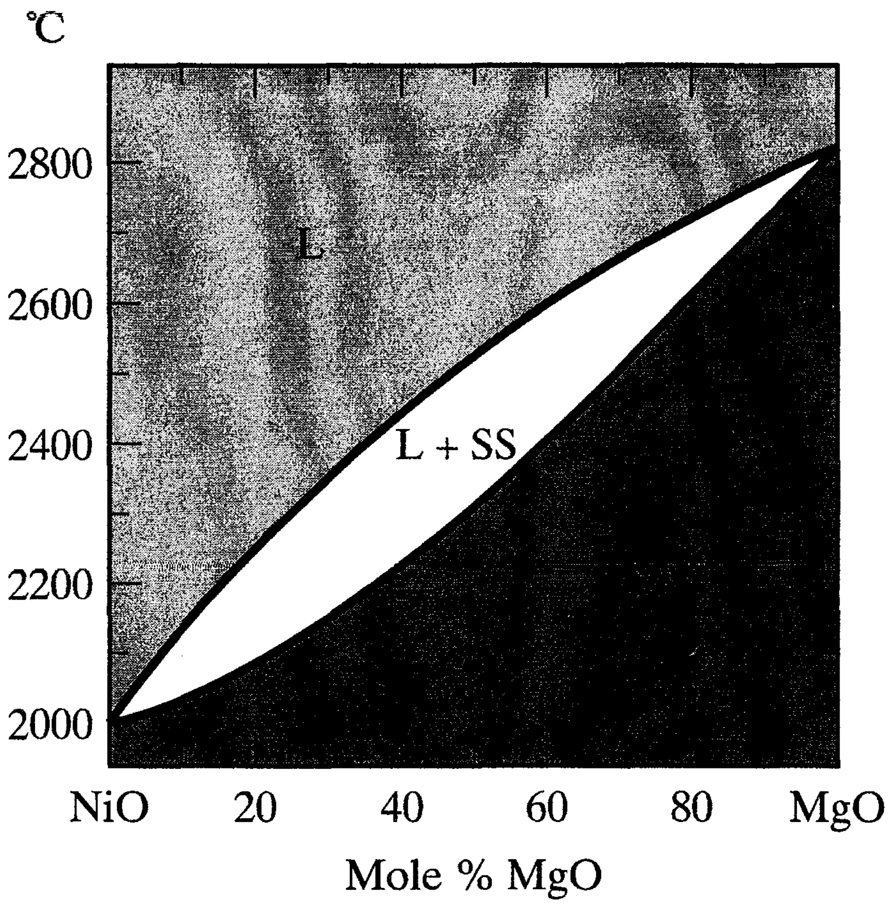

Figure 4 - NiO-MgO phase diagram

3. [a] Cooling curves are obtained for a series of Cu-Ag alloys (Fig 5). Use this data to produce the Cu-Ag phase diagram. The maximum solubility of Ag in Cu is 7.9% and the maximum solubility of Cu in Ag is 8.8%. The solubilities at room temperature are near zero.

(50 marks)

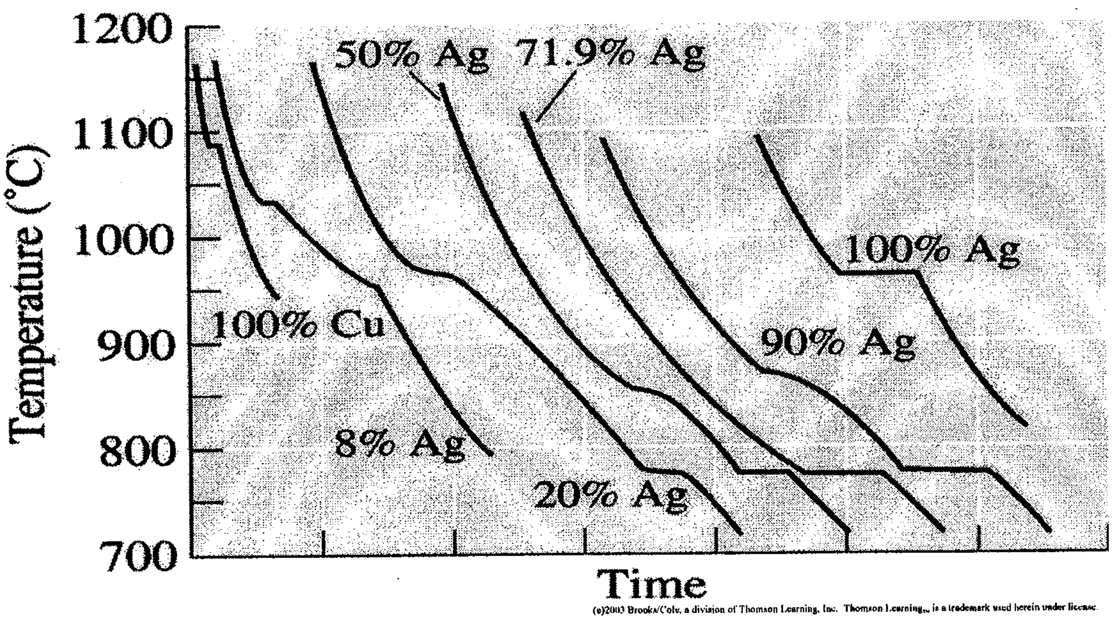

Figure 5 - Cooling curves for a series of Cu-Ag alloys

[b] The ideal stoichiometry of the γ phase in the Al-Mg system is $Al_{12}Mg_{17}$. (a) What is the atomic percentages of excess Al in the most aluminium-rich γ composition at 450°C (b) What is the atomic percentages of excess Mg in the most magnesium-rich γ composition at 437°C? (see Fig. 6)

(50 marks)

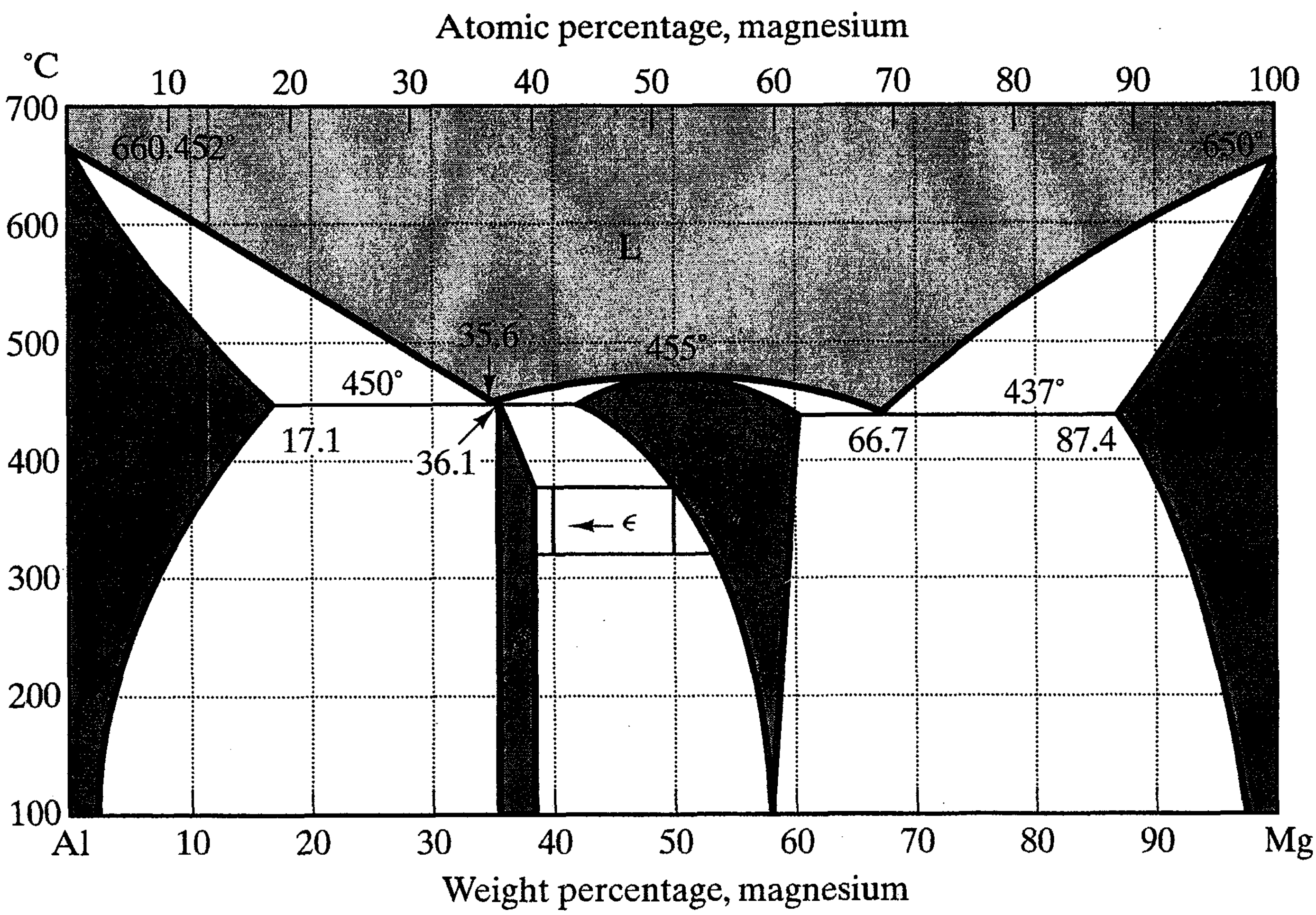

Figure 6 - Al-Mg phase diagram

4. [a] Figure 7 shows the sigmoidal curve for the transformation of austenite. Determine the constants c and n in Equation 11-2 for this reaction. By comparing this figure with the TTT diagram (Figure 8), estimate the temperature at which this transformation occurred.

(50 marks)

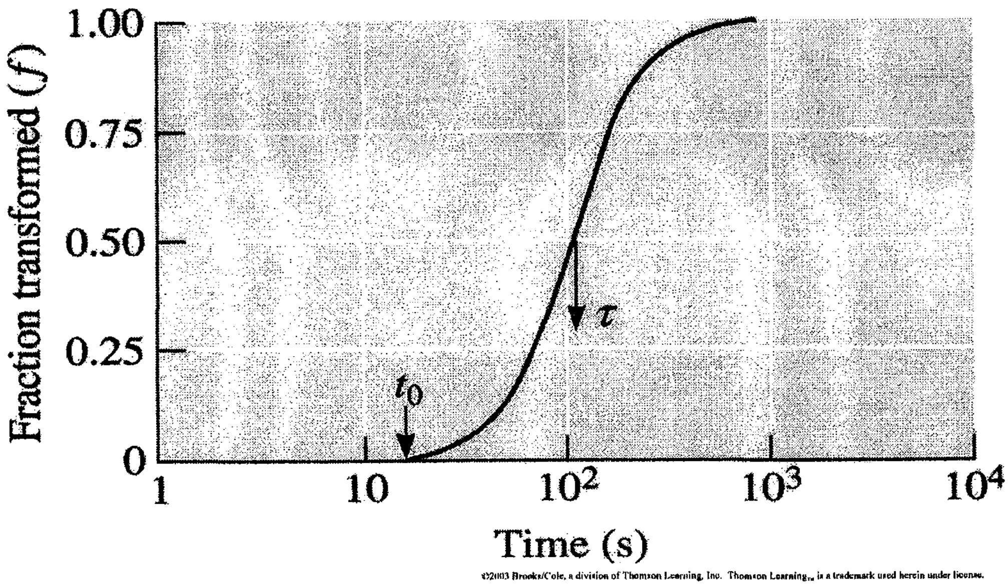

Figure 7

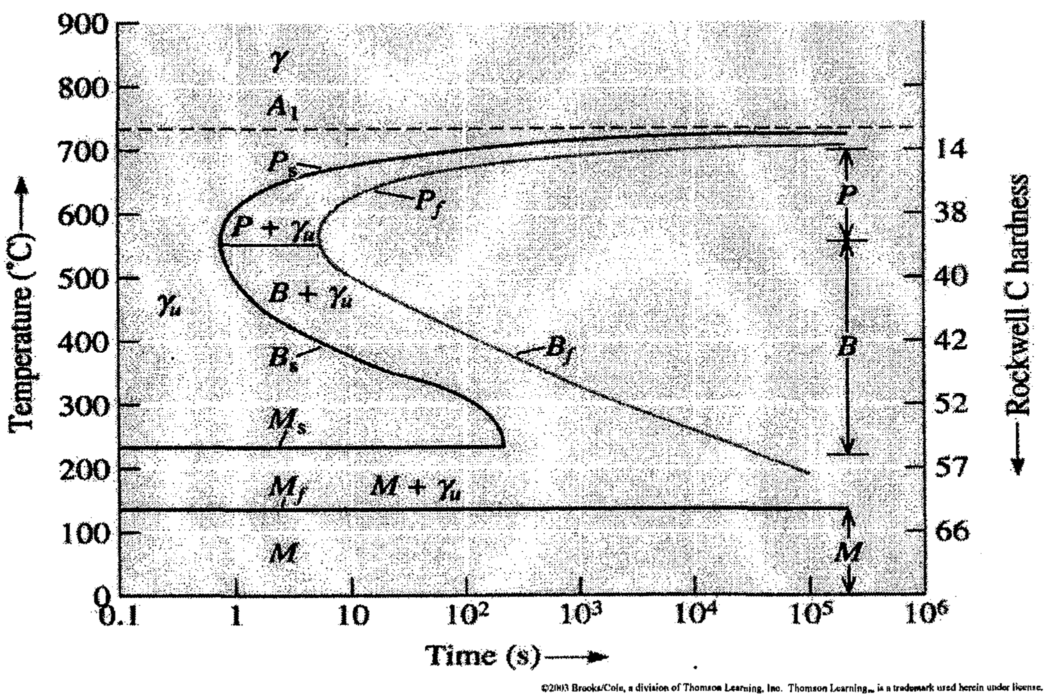

Figure 8

[b] For an aluminum alloy, the activation energy for crystal growth is 120 kJ/mol. By what factor would the rate of crystal growth change by dropping the alloy temperature from 500°C to room temperature (25°C)?

(30 marks)

[c] Briefly describe what is diffusional transformation and diffusionless transformation. Give examples.

(20 marks)

5. In the system ABC, a ternary alloy containing 40% B and 8% C under-goes a eutectic reaction L $\rightarrow \alpha + \beta$ over the temperature range 550-500°C as part of its solidification sequence. The compositions of the phases coexisting in equilibrium at 540°C and 510°C are as follow :

	α	β	L
540°C	85%A, 10%B, 5%C	5%A, 93%B, 2%C	55%A, 30%B, 15%C
510°C	82%A, 11%B, 7%C	6%A, 89%B, 5%C	48%A, 32%B, 20%C

Calculate :

(a) The proportions by weight of α and β phases present in the alloy at 540°C.

(50 marks)

(b) The ratio of the proportions of liquid phase present at 540°C and 510°C.

(50 marks)

6. A ternary system ABC shows complete solubility in the liquid state and contains only two solid phases, which are solid solutions designated α and β respectively. The melting points of components A, B and C are 1100°C, 900°C and 800°C, respectively. The binary system BC shows complete solid solubility, while systems AB and AC each contain an invariant reaction as follows :

	Temperature of invariant reaction	Compositions of the phases involved in invariant reaction		
		α	β	Liquid
System AB	850°C	95%A, 5%B	10%A, 90%B	50%A, 50%B
System AC	750°C	97%A, 3%C	12%A, 88%C	60%A, 40%C

Sketch and label :

(a) Possible liquidus and solidus projections for the ternary system.

(50 marks)

(b) By reference to these projections, describe the solidification sequence of an alloy containing 30%A, 55%B and 15%C, under equilibrium conditions; estimate the proportions of the phases present at completion of solidification.

(50 marks)

7.

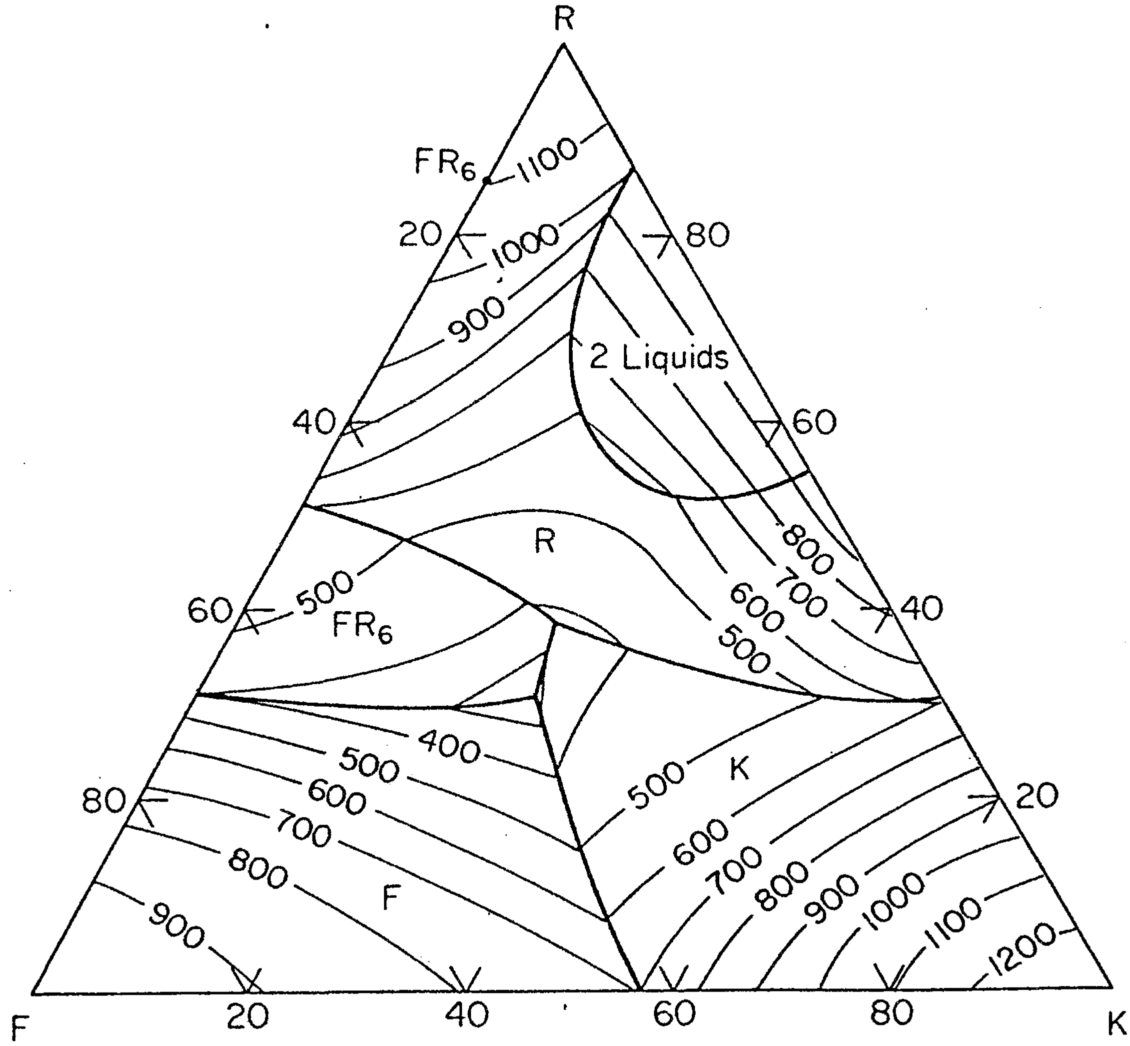

Figure 9

[a] Indicate the cooling path for a melt of composition R = 60%, F = 20%, K = 20%.

(50 marks)

[b] Calculate the percent of each phase present at 700°C.

(25 marks)

[c] Calculate the composition of each phase present at 700°C.

(25 marks)

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