/18

1+6+6 /13

1. For the phase diagram shown below, state what phases are present and the compositions of each phase at that given point:
   a. 30wt% Pb – 70 wt% Mg at 400˚C
   b. 12 mol Pb + 100 mol Mg at 505˚C
   c. 47g Pb + 10g Mg at 150˚C
   d. For the scenarios given in (b) and (c), calculate the mass fraction and volume fraction of the phases present. For calculation of the volume fraction, implement the equation shown below assuming the densities of Pb and Mg to be 11.34 g/cm³ and 1.738g/cm³, respectively.

$$\rho_{avg} = \frac{100}{\frac{C_1}{\rho_1} + \frac{C_2}{\rho_2}}$$

1

a) α -> 30 wt% Pb, 70wt% Mg.

b) convert mol to g & find $m_{Pb} = 2486 g$ 1 $m_T = 4941.205$

$m_{Mg} = 2454.85 g$

∴ $C_{Pb} = 50.32\%$, $C_{Mg} = 49.68\%$

α + L present at this composition

α at 33% Pb, 67% Mg.

1

L at 62% Pb, 38% Mg.

$$W_\alpha = \frac{C_L - C_o}{C_L - C_\alpha} = \frac{62-50}{62-33} = \frac{12}{29} = 41.37\%$$

1

$$W_L = \frac{C_o - C_\alpha}{C_L - C_\alpha} = \frac{50-33}{62-33} = \frac{17}{29} = 58.6\%$$

$$\rho_\alpha = \frac{100}{\left(\frac{33}{11.34}\right) + \left(\frac{67}{1.738}\right)} = \frac{100}{(2.91 + 38.55)} = 2.42 g/cm^3$$ 1 & $\rho_L = 3.66 g/cm^3$

1

$$V_\alpha = \frac{\frac{W_\alpha}{\rho_\alpha}}{\frac{W_\alpha}{\rho_\alpha} + \frac{W_L}{\rho_L}} = \frac{\left(\frac{0.4137}{2.42}\right)}{\left(\frac{0.4137}{2.42}\right) + \left(\frac{0.586}{3.66}\right)}$$

1

$$= \frac{0.1709}{0.331} = 51.65\%$$

$\therefore V_L = 48.35\%$

6

c) 47g Pb + 10g Mg.

1

$C_{Pb} = \frac{47}{57} = 82.45\%$ $C_{Mg} = 17.55\%$

at this → β + Mg_2Pb present

1

β at 98% Pb, 2% Mg.

Mg_2Pb at 81% Pb, 19% Mg.

1

1

$W_\beta = \frac{82.45 - 81}{98 - 81} = 0.085$ & $W_{Mg_2Pb} = 0.915$

$= 8.5\%$ $= 91.5\%$

1

$\rho_\beta = \frac{100}{\left(\frac{98}{11.34}\right) + \left(\frac{2}{1.738}\right)} = 10.45\,g/cm^3$ & $\rho_{Mg_2Pb} = 5.53\,g/cm^3$

$V_\beta = 4.69\%$ & $V_{Mg_2Pb} = 95.31\%$ 1

3

2. 1.5 kg of a 90wt% lead in a lead/tin alloy is placed in a furnace at 250˚C. Your goal with this alloy is to transition it to a stage at which 50% of the alloy will be a liquid phase. This can be done through one of two methods, which each require you to state the following values:
    a. Heating the alloy further from 250˚C to a T2. What temperature would yield a 50% liquid composition?
    b. Adding additional tin to the alloy at the same temperature. How much tin do you need to add in order to achieve a 50% liquid composition?

1

a) By trial & error using the phase diagram, you can heat this to ~295°C to achieve 50% liquid

b) $C_\alpha = 14\text{wt\% } Sn$ & $C_L = 34\text{wt\% } Sn$ 1

$$W_\alpha = 0.5 = \frac{C_L - C_0}{C_L - C_\alpha} = \frac{34 - C_0}{34 - 14}$$

$\therefore C_0 = 24 \text{ wt\%}$

$(0.1)(1.5\text{kg}) = 0.15\text{kg}$ of Sn in alloy 1

& $\left[\dfrac{0.15\text{kg} + m_{Sn}}{1.5\text{kg} + m_{Sn}}\right] \times 100\% = 24$

$\therefore m_{Sn} = 0.276\text{kg}$

1

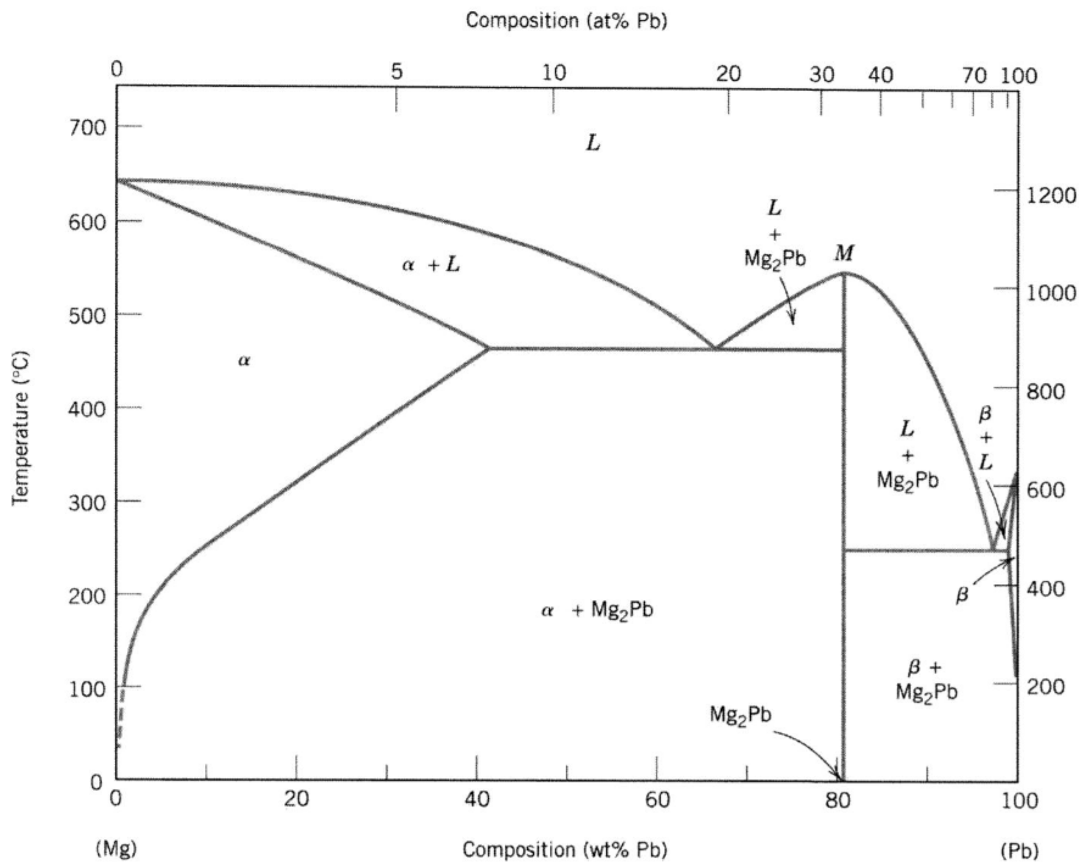
3. Explain why a eutectic alloy will form a lameller structure as opposed to a different microstructure when solidifying?

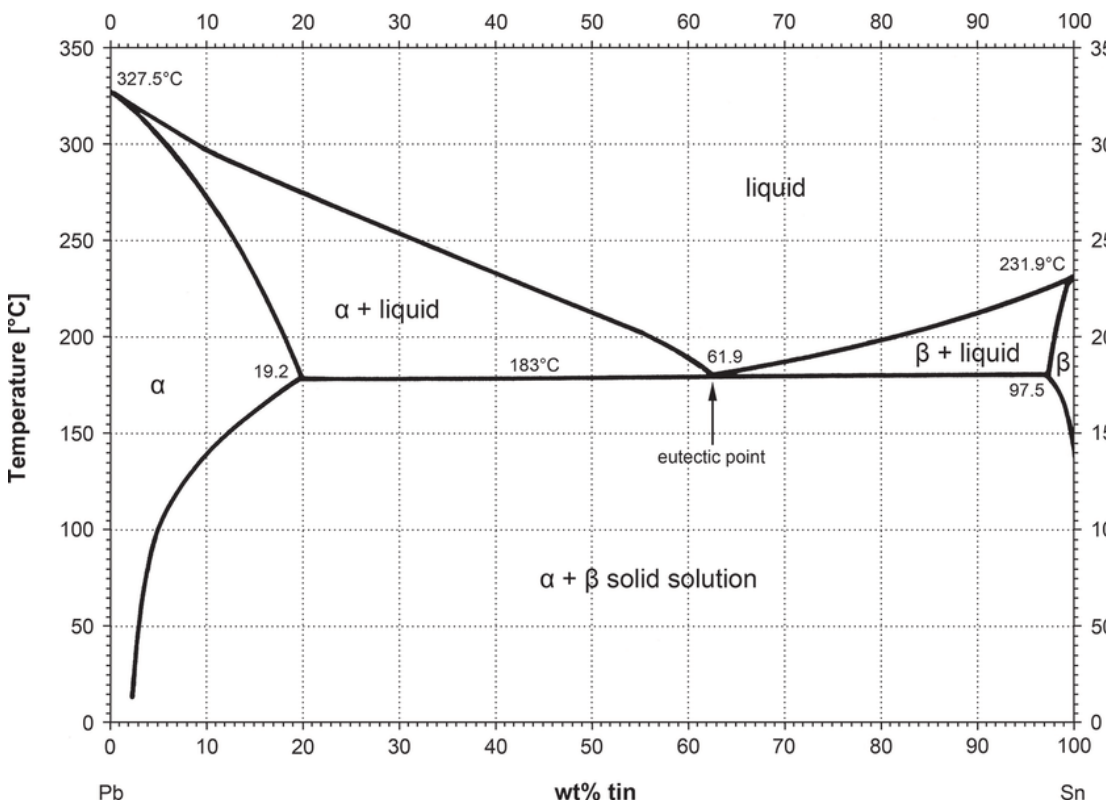
An alloy of eutectic composition forms a microstructure of alternating layers of the two solid phases because of diffusion. The layered configuration of a lamellar microstructure minimizes the diffusion path length for the atoms during solidifcation. .

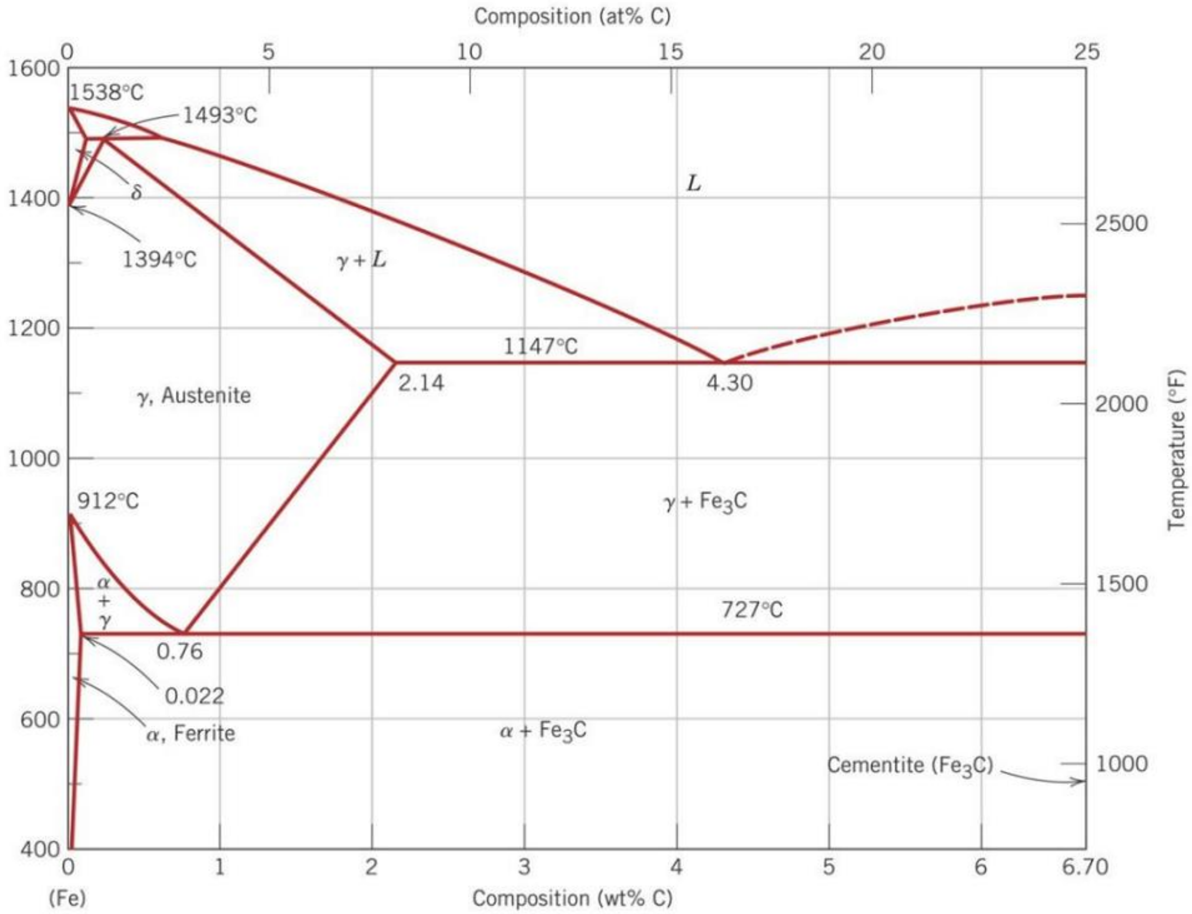
1

4. A 1wt% C steel alloy is being used to manufacture a fuel door on an automobile. If this steel alloy is being heated to 1200˚C during a stamping process, would you be able to predict the composition of the phases present on the finished product?

Although an attempt could be made using a phase diagram, the correct answer is to predict that it cannot be predicted. This is because a phase diagram does not contain information in terms of the kinetic of cooling, including the cooling rate. Other diagrams exist for properly doing this, such as time-temperature transformation (TTT) and continuous cooling diagrams (CCT).


Composition (at% Pb)
0
5
10
20
30
40
70
100
700
600
500
400
300
200
100
0
L
α + L
L
+
Mg2Pb
M
α
L
+
Mg2Pb
β
+
L
1200
1000
800
600
400
200
β
α + Mg2Pb
β +
Mg2Pb
Mg2Pb
Temperature (°C)
Temperature (°F)
0
20
40
60
80
100
(Mg)
Composition (wt% Pb)
(Pb)


0
10
20
30
40
50
60
70
80
90
100
350
300
250
200
150
100
50
0
327.5°C
liquid
231.9°C
α + liquid
β + liquid
β
α
19.2
183°C
61.9
97.5
eutectic point
α + β solid solution
Temperature [°C]
Pb
wt% tin
Sn



<u>Additional Problems</u>

1. Show a proof of the lever rule
2. A magnesium-lead alloy of mass 5.5 kg consists of a solid α phase that has a composition that is just slightly below the solubility limit at 200°C (390°F).
    a. What mass of lead is in the alloy?
    b. If the alloy is heated to 350°C (660°F), how much more lead may be dissolved in the α phase without exceeding the solubility limit of this phase?
3. For a steel alloy containing 0.35 wt% carbon at 720˚C, determine the following:
    a. The fractions of total ferrite and cementite phases
    b. The fractions of the proeutectoid ferrite and pearlite (Hint: To do this, assume that the tie line extends to only the point where you obtain a eutectoid composition)
    c. The fraction of eutectoid ferrite