Fundamentals of Materials Science Homework 19

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Homework Problems:

1. Compute the mass fraction of α ferrite and cementite in pearlite.

Solution:

$$W_\alpha = \frac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \frac{6.70 - 0.76}{6.70 - 0.022} = 0.89$$

$$W_{Fe_3C} = \frac{C_0 - C_\alpha}{C_{Fe_3C} - C_\alpha} = \frac{0.76 - 0.022}{6.70 - 0.022} = 0.11$$

2. What is the carbon concentration of an iron-carbon alloy in which the mass fractions of total ferrite is 0.94?

Solution:

$$W_\alpha = \frac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \frac{6.70 - C_0}{6.70 - 0.022} = 0.94 \quad ; \quad \therefore C_0 = 0.42$$

3. The proeutectoid phase could be proeutectoid ferrite or proeutectoid cementite depending on the different C content. What is the proeutectoid phase for an iron-carbon alloy in which the mass fractioin of total ferrite and total cementite are 0.92 and 0.08, respectively? Why?

Solution:

$$W_\alpha = \frac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \frac{6.70 - C_0}{6.70 - 0.022} = 0.92 \quad ; \quad \therefore C_0 = 0.56$$

∴the proeutectoid phase is proeutectoid ferrite.

4. Consider 1.0 kg of austenite containing 1.15 wt% C, cooled to below 727°C (1341°F).
(a) What is the proeutectoid phase?
(b) How many kilograms each of total ferrite and cementite form?

(c) How many kilograms each of pearlite and the proeutectoid phase form?

(d) Schematically sketch and label the resulting microstructure.

Solution:

(a) 1.15 wt% C is between 0.76 and 2.14 wt% C, so the proeutectoid phase is proeutectoid cementite.

(b). $W_\alpha = \dfrac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \dfrac{6.70 - 1.15}{6.70 - 0.022} = 0.83$

$$W_{Fe_3C} = \frac{C_0 - C_\alpha}{C_{Fe_3C} - C_\alpha} = \frac{1.15 - 0.022}{6.70 - 0.022} = 0.17$$

$$\therefore M_\alpha = 1kg \times 0.83 = 0.83kg$$

$$\therefore M_{Fe_3C} = 1kg \times 0.17 = 0.17kg$$

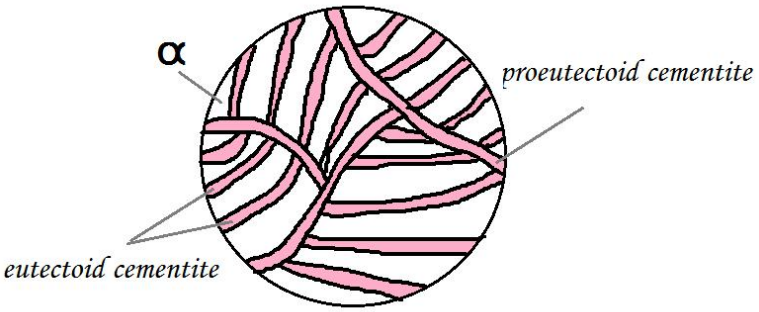
(c). $W_{pearlite} = \dfrac{6.7 - 1.15}{6.7 - 0.76} = 0.93$

$$W_{proeutectoid} = \frac{1.15 - 0.76}{6.7 - 0.76} = 0.07$$

So, $m_{pearlite} = 1kg \times 0.93 = 0.93\text{kg}$

$$m_{proeutectoid} = 1kg \times 0.07 = 0.07\text{kg}$$

(d)



5. Compute the mass fractions of proeutectoid ferrite and pearlite that form in an iron–carbon alloy containing 0.25 wt% C.

Solution:

$$W_{proeutectoid} = \frac{0.76 - 0.25}{0.76 - 0.022} = 0.69$$

$$W_{pearlite} = \frac{0.25 - 0.022}{0.76 - 0.022} = 0.31$$

6. Consider 2.0 kg of a 99.6 wt% Fe–0.4 wt% C alloy that is cooled to a temperature just below the eutectoid. (a) How many kilograms of proeutectoid ferrite form? (b) How many kilograms of eutectoid ferrite form? (c) How many kilograms of cementite form?

Solution:

(a) $$W_{proeutectoid} = \frac{0.76 - 0.4}{0.76 - 0.022} = 0.49$$

$$m_{proeutectoid} = 2kg \times 0.49 = 0.98\text{kg}$$

(b) $$W_{\text{total}} = \frac{6.7 - 0.4}{6.7 - 0.022} = 0.94$$

$$\text{W}_{eutectoid} = W_{total} - W_{proeutectoid} = 0.94 - 0.49 = 0.45$$

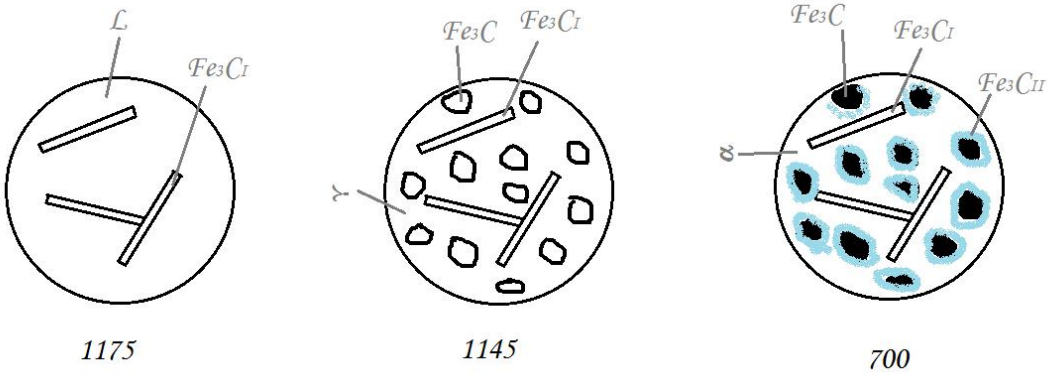
$$m_{cementite} = 2kg \times 0.45 = 0.9\text{kg}$$

(c) $$W_{\text{cementite}} = \frac{0.4 - 0.022}{6.7 - 0.022} = 0.06$$

$$m_{cementite} = 2kg \times 0.06 = 0.12\text{kg}$$

7. For an iron–carbon alloy of composition 5 wt% C–95 wt% Fe, make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at the following temperatures: 1175°C (2150°F), 1145°C (2095°F), and 700°C (1290°F). Label the phases and indicate their compositions (approximate).

Solution:



8. 总结各种铁碳合金的室温平衡显微组织是什么，填写在下表中。

铁碳合金	亚共析钢	共析钢	过共析钢	亚共晶白口铁	共晶白口铁	过共晶白口铁
室温平衡显微组织	铁素体 + 珠光体	珠光体	珠光体 + 二次渗碳体	珠光体 + 二次渗碳体 + 变态莱氏体	莱氏体	莱氏体 + 一次渗碳体

9. 自己画一个铁碳相图，可以用计算机绘制，也可以用笔和尺子绘制，看谁画得最 **professional**。但是不能去网上复制一个或者复印扫描书上的，一定是你自己亲笔画的。请在你绘制的铁碳相图中标出下面内容：

（1）液相线和固相线

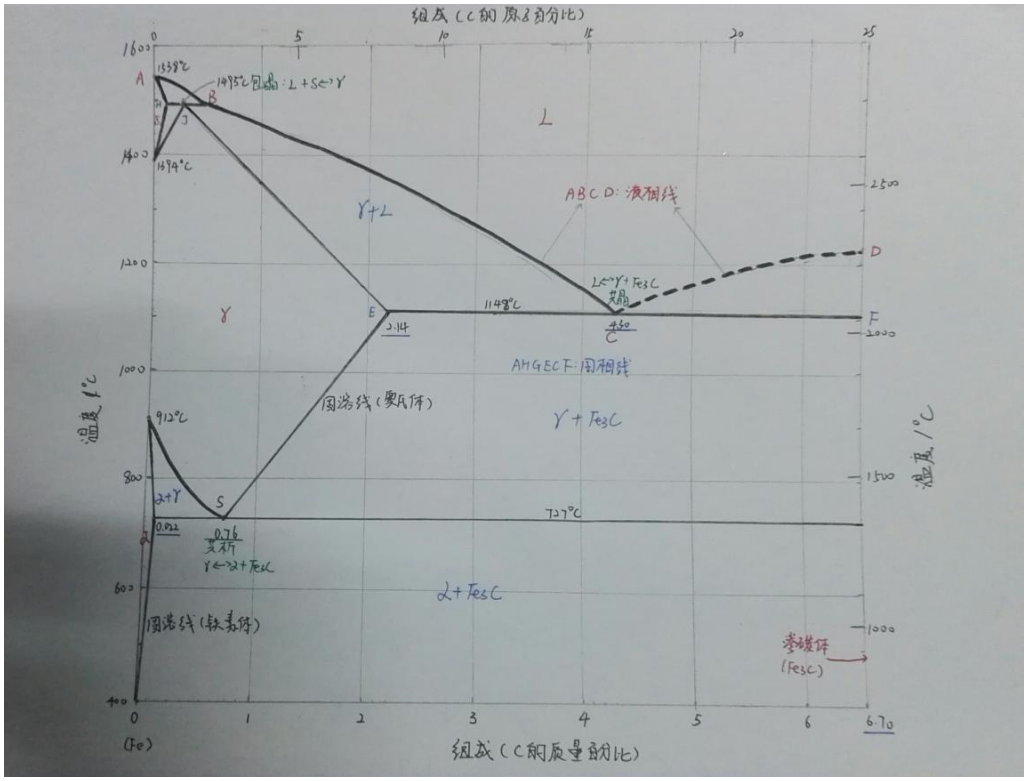
（2）三个恒温反应：包晶，共析，共晶。三个重要温度：**1495°C, 1148 °C, 727 °C.**

（3）固溶线：**C** 在奥氏体中和 **C** 在铁素体中的固溶线。

（4）单相区和两相区

（5）五个重要的成分点：含碳量为 **0.22%, 0.77%, 2.11%, 4.3%, 6.7%**的点。

Solution:



10. 在亚共析钢、共析钢、过共析钢、亚共晶白口铁、共晶白口铁、过共晶白口铁六种典型的铁碳合金中，选择一个论述其平衡凝固过程中显微组织的演变，并描绘其结晶过程的示意图。

Solution:

共析钢：0.76wt%C 降温至 1480℃时，液相中出现奥氏体。降低至 1400℃左右，液相全部变为奥氏体相。继续降温至 727℃，发生共析。奥氏体共析出铁素体和渗碳体，铁素体、渗碳体薄层交错相叠成为珠光体。