# MAE20 Homework 6 Solutions

10-16 Determine the liquidus temperature, solidus temperature, and freezing range for the following MgO-FeO ceramic compositions. (See Figure 10-17).

(a) MgO-25 wt% FeO (b) MgO-45 wt% FeO
(c) MgO-65 wt% FeO (d) MgO-80 wt% FeO

Solution:

(a) $T_L = 2600°C$ $T_S = 2230°C$ $FR = 370°C$

(b) $T_L = 2340°C$ $T_S = 1900°C$ $FR = 440°C$

(c) $T_L = 2000°C$ $T_S = 1610°C$ $FR = 390°C$

(d) $T_L = 1750°C$ $T_S = 1480°C$ $FR = 270°C$

10-19 A Nb-60 wt% W alloy is heated to 2800°C. Determine (a) the composition of the solid and liquid phases in both wt% and at% and (b) the amount of each phase in both wt% and at%. (c) Assuming that the density of the solid is 16.05 g/cm$^3$ and that of the liquid is 13.91 g/cm$^3$, determine the amount of each phase in vol%. (See Figure 10-18).

Solution:

(a) L: 49 wt% W $\quad$ at% W $= \dfrac{49/183.85}{(49/183.85) + (51/92.91)} \times 100\% = 32.7\%$

$\alpha$: 70 wt% W $\quad$ at% W $= \dfrac{(70/183.85)}{(70/183.85) + (30/92.91)} \times 100\% = 54.1\%$

(b) wt% L $= \dfrac{70 - 60}{70 - 49} \times 100\% = 47.6\%$ $\quad$ wt% $\alpha = 52.4\%$

The original composition, in wt% MgO, is:

$$\frac{60 / 183.85}{(60 / 183.85) + (40 / 92.91)} \times 100\% = 43.1\%$$

at% L $= \dfrac{54.1 - 43.1}{54.1 - 32.7} \times 100\% = 51.4\%$ $\quad$ wt% $\alpha = 48.6\%$

(c) Vol% L $= \dfrac{47.6/13.91}{\phantom{0}} \times 100\% = 51.2\%$ $\quad$ Vol% $\alpha = 48.8\%$

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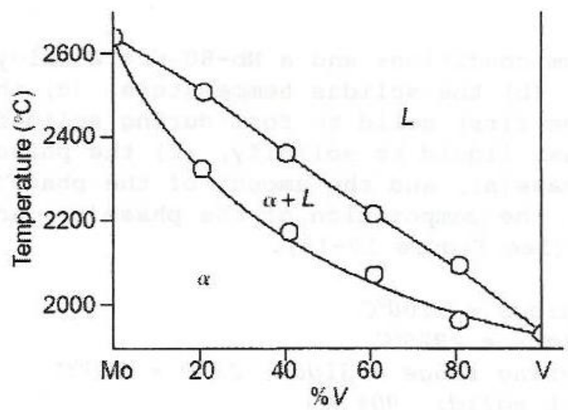
10-40 Cooling curves are shown in Figure 10-21 for several Mo-V alloys. Based on these curves, construct the Mo-V phase diagram.

Solution:

| | $T_{Liquidus}$ | $T_{Solidus}$ |
|---|---|---|
| 0% V | 2630°C | |
| 20% V | 2500°C | 2320°C |
| 40% V | 2360°C | 2160°C |
| 60% V | 2220°C | 2070°C |
| 80% V | 2100°C | 1970°C |
| 100% V | 1930°C | |



11-7 A hypothetical phase diagram is shown in Figure 11-25. (a) Are any intermetallic compounds present? If so, identify them and determine whether they are stoichiometric or nonstoichiometric. (b) Identify the solid solutions present in the system. Is either material *A* or *B* allotropic? Explain. (c) 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.

Solution:

*(a)* $\theta$ = *non-stoichiometric*

*(b)* $\alpha$, $\eta$, $\gamma$, *and* $\beta$; *material B is allotropic, existing in three different forms at different temperatures*

*(c)* 1100°C: $\gamma + L \rightarrow \beta$; *peritectic;* L: 82% B  $\gamma$: 97% B  $\beta$: 90% B

900°C: $L_1 \rightarrow L_2 + \alpha$; *monotectic;* $L_1$: 28% B  $L_2$: 50% B  $\alpha$: 5% B

680°C: $L \rightarrow \alpha + \beta$; *eutectic;* L: 60% B  $\alpha$: 5% B  $\beta$: 90% B

600°C: $\alpha + \beta \rightarrow \theta$; *peritectoid;* $\alpha$: 5% B  $\beta$: 80% B  $\theta$: 37% B

300°C: $\beta \rightarrow \theta + \eta$; *eutectoid;* $\beta$: 90% B  $\theta$: 40% B  $\eta$: 95% B

11-9 The Al-Li phase diagram is shown in Figure 11-27. (a) Are any intermetallic compounds present? If so, identify them and determine whether they are stoichiometric or nonstoichiometric. Determine the formula for each compound. (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.

Solution:

*(a)* $\beta$ *is non-stoichiometric @ 21 wt% Li:*

$$\text{at\% Li} = \frac{21\text{ g} / 6.94\text{ g/mol}}{21/6.94 + 79/26.981} \times 100\% = 50\text{ at\% Li} \therefore AlLi$$

$\gamma$ *is stoichiometric @ 34 wt% Li:*

$$\text{at\% Li} = \frac{34\text{ g} / 6.94\text{ g/mol}}{34/6.94 + 66/26.981} \times 100\% = 66.7\%\text{ Li} \therefore AlLi_2$$

*(b)* 600°C: $L \rightarrow \alpha + \beta$  *eutectic*  L: 9.9% Li  $\alpha$: 4% Li  $\beta$: 20.4% Li

510°C: $\beta + L \rightarrow \gamma$  *peritectic*  $\beta$: 25% Li  L: 47% Li  $\gamma$: 34% Li

170°C: $L \rightarrow \gamma + \alpha(L_1)$  *eutectic*  L: 98% Li  $\gamma$: 34% Li  $\alpha(L_1)$: 99% Li