MAT E 201: Solution to Assignment #5

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Assign. #5 MAT E 201 Dr. S. Djokić

Q1 Diffusion of H and N in FCC Fe at 1200°C

$D = D_0 \exp(-Q/RT)$

H in FCC Fe (Table 5-1)

$D_0 = 0.0063\ cm^2/s$ $Q = 10300\ cal/mol$, $1\ cal = 4.186\ J$

$Q = 43115.8\ J/mol$

$$D_H = 0.0063 \exp\left(-\frac{43115.8}{8.314 \cdot 1473}\right) = 1.86354 \cdot 10^{-4}\ cm^2/s$$

N in FCC Fe

$D_0 = 0.0034\ cm^2/s$

$Q = 34600\ cal/mol = 144835.6\ J/mol$

$$D_N = 0.0034 \exp\left(-\frac{144835.6}{8.314 \cdot 1473}\right) = 2.4844 \cdot 10^{-8}\ cm^2/s$$

$r_N = 0.71\ \mathring{A} > r_H = 0.46\ \mathring{A}$

Smaller H atoms diffuse more rapidly than nitrogen ion.

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Q2 $C_0 = 0.02\%$, $C_x = 0.45\%$, $x = 0.6 mm = 0.06 cm$

$$\frac{C_s - C_x}{C_s - C_0} = erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

$$\frac{C_s - 0.45}{C_s - 0.02} = erf\left(\frac{0.06}{2\sqrt{Dt}}\right), \quad D = D_0 \exp(-Q/RT)$$

$Q = 32900\ cal/mol = 1.377194 \cdot 10^5\ J/mol$

$D_0 = 0.23\ cm^2/s$, $R = 8.314\ J/mol\,K$, $T = 1473\ K$

$$D = 0.23 \exp\left(-\frac{1.377194 \cdot 10^5}{8.314 \cdot 1473}\right) = 3 \cdot 10^{-6}\ cm^2/s$$

$t = 4h = 4 \cdot 3600\ s = 14400\ s$

$$\sqrt{Dt} = \sqrt{3 \cdot 10^{-6} \cdot 14400} = 0.2078$$

$$erf\left(\frac{0.06}{2 \cdot 0.2078}\right) = erf(0.144) = 0.161$$

$$\frac{C_s - 0.45}{C_s - 0.02} = 0.161 \implies C_s = 0.53\%$$

Q 3 Largest solubility in CaO $r_{Ca^{2+}} = 0.99\,\mathring{A}$

a) MgO , b) NiO , c) FeO $r_{O^{2-}} = 1.32\,\mathring{A}$

$$r_{Mg^{2+}} = 0.66\,\mathring{A} \; ; \; r_{Ni^{2+}} = 0.69\,\mathring{A}$$

$$r_{Fe^{2+}} = 0.74\,\mathring{A}$$

a) MgO $$\Delta r = \frac{r_{Ca^{2+}} - r_{Mg^{2+}}}{r_{Ca^{2+}}} = \frac{0.99-0.66}{0.99} = 33.33\%$$

b) NiO $$\Delta r = \frac{r_{Ca^{2+}} - r_{Ni^{2+}}}{r_{Ca^{2+}}} = \frac{0.99-0.69}{0.99} = 30.30\%$$

c) FeO $$\Delta r = \frac{r_{Ca^{2+}} - r_{Fe^{2+}}}{r_{Ca^{2+}}} = \frac{0.99-0.74}{0.99} = 25.25\%$$

We would expect FeO to have the largest solid solubility

Q4. a) $MgO - 10wt\% FeO$

$T_L = 2750°C$, $T_S = 2550°C$, $FR = T_L - T_S = 200°C$

b) $MgO - 45wt\% FeO$

$T_L = 2300°C$, $T_S = 1900°C$, $FR = 400°C$

c) $MgO - 60wt\% FeO$

$T_L = 2100°C$, $T_S = 1700°C$, $FR = 400°C$

d) $MgO - 80wt\% FeO$

$T_L = 1550°C$, $T_S = 1400°C$, $FR = 150°C$

Q5. a)

i) $MgO - 20wt\% FeO$ at $2000°C$ $\Rightarrow$ 100% S

ii) $MgO - 50wt\% FeO$ at $2000°C$

$S = 40\% FeO$, $L = 65\% FeO$

$$\%S = \frac{65-50}{65-40} \cdot 100\% = 60\%; \quad \%L = \frac{50-40}{65-40} \cdot 100\% = 40\%$$

iii) $MgO - 60wt\% FeO$ at $2000°C$

$S = 40\% FeO$, $L = 65\% FeO$

$$\%S = \frac{65-60}{65-40} \cdot 100\% = 20\%; \quad \%L = \frac{60-40}{65-40} \cdot 100\% = 80\%$$

iv) $MgO - 90wt\% FeO$ $\Rightarrow$ 100% L

Q5 b) 40 wt% Au 60 wt% Ag

$A_r(Au) = 196.97\,g/mol$; $A_r(Ag) = 107.868\,g/mol$

$$at\%\,Au = \frac{\frac{40}{196.97}}{\frac{40}{196.97} + \frac{60}{107.868}} \cdot 100\% = 26.74\,at\%$$

$$at\%\,Ag = \frac{\frac{60}{107.868}}{\frac{40}{196.97} + \frac{60}{107.868}} \cdot 100\% = 73.26\,at\%$$