

Example exam 1 solutions

1.

① Foil $25\mu\text{m} \times 1\text{cm} \times 1\text{cm}$ BCC iron $r = 0.124\text{nm}$

$$a = \frac{4}{\sqrt{3}} r = \frac{4}{\sqrt{3}} (0.124\text{nm}) = 0.286\text{nm}$$

$$(\# \text{ cells}) (0.286 \times 10^{-6}\text{m}) = 25 \times 10^{-6}\text{m} \Rightarrow \# \text{ cells in foil thickness} = \boxed{8.73 \times 10^4}$$

$$\left. \begin{array}{l} V_{\text{foil}} = 2.5 \times 10^{-3} \text{cm}^3 \\ V_{\text{cell}} = 2.34 \times 10^{-23} \text{cm}^3 \end{array} \right\} n_{\text{cells}} (2.34 \times 10^{-23} \text{cm}^3) = 2.5 \times 10^{-3} \text{cm}^3$$

$$\Rightarrow \# \text{ cells in foil} = \boxed{1.06 \times 10^{20}}$$

2.

② $C_x = 0.50 \text{ wt\%}$ $x = 0.5 \text{ mm}$ $C_0 = 0.2 \text{ wt\%}$ $t = 5 \text{ hrs}$ $C_s = 0.71 \text{ wt\%}$
 $D = D_0 \exp\left(\frac{-Q}{RT}\right)$ $Q = 134,000 \text{ J/mole}$ $R = 8.314 \text{ J/mole}\cdot\text{K}$ $T = ?$

$$\frac{C_x - C_0}{C_s - C_0} = 1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right) \Rightarrow \frac{0.5 - 0.2}{0.71 - 0.2} = 1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

$$\Rightarrow \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right) = 0.588$$

Table:	z	erf(z)	Linear interpolation
	0.55	0.5633	
	y	0.588	$\frac{0.588 - 0.5633}{y - 0.55} = \frac{0.6039 - 0.5633}{0.60 - 0.55}$
	0.60	0.6039	

$$y = \frac{x}{2\sqrt{Dt}} = 0.5804$$

$$\frac{0.5 \times 10^{-3} \text{m}}{2\sqrt{(0.23 \times 10^{-4} \frac{\text{m}^2}{\text{sec}}) \left[\exp\left(\frac{-134,000 \text{ J/mole}}{8.314 \frac{\text{J}}{\text{mole}\cdot\text{K}} \cdot T}\right) \right] (3600 \text{ sec}) (5 \text{ hr})}} = 0.5804$$

$$\Rightarrow \boxed{T = 1102 \text{ K} = 830^\circ\text{C}}$$

3.

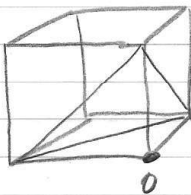
$$n_v = 10^{-3} \text{ at } 650^\circ\text{C} = 923\text{K}$$

$$n_v = \exp\left(\frac{-Q}{kT}\right) = 10^{-3} = \exp\left(\frac{-Q}{8.62 \times 10^{-5} \frac{\text{eV}}{\text{K}} \cdot 923\text{K}}\right)$$

$$\Rightarrow \boxed{Q = 0.55 \text{ eV}}$$

4.

Plane A



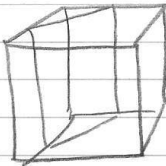
x-intercept = -1
y-intercept = -1
z-intercept = 1

reciprocals

-1
-1
1

$$\boxed{(111)}$$

Plane B



x-intercept = 1/2
y-intercept = 1/2
z-intercept = ∞

reciprocals

2
2
0

$$\text{Plane } \boxed{(220)}$$

5.

• (c) (111)

• (a) metallic, covalent, ionic

• (b) energy at a minimum

• T

• (c) lattice parameter } can't calculate density unless atomic wt is known