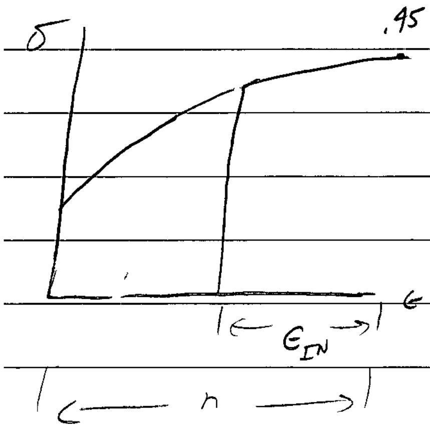
1. $d_0 = .505''$  $F_Y = 4000$ lbf  $\Delta A = 20\%$

a. $Y = \frac{F}{A} = \frac{4000}{\frac{\pi}{4}(.505)^2} = 19{,}970$ psi ✓

b. $\sigma = K\epsilon^n$  $n = .45$




$\epsilon_{IN} = \ln\frac{A_0}{A} = \ln\left(\frac{1}{(1-.2)}\right)$

$= .223$

$\epsilon_0 = .45 - .223 = .227$ ✓

$\boxed{\epsilon_0 = .227}$

c. $\sigma = K\epsilon^n$

$K = \frac{\sigma}{\epsilon^n} = \frac{Y}{\epsilon_Y^n} = \frac{19{,}970 \text{ lb/in}^2}{(.227)^{.45}} = 38{,}920$ psi ✓

10/10

2.

a) $d\bar{\varepsilon} = \sqrt{\frac{2}{3}(d\varepsilon_1^2 + d\varepsilon_2^2 + d\varepsilon_3^2)}$

$d\varepsilon_2 = 0 \qquad d\varepsilon_1 + \underset{0}{d\varepsilon_2} + d\varepsilon_3 = 0 \Rightarrow d\varepsilon_1 = -d\varepsilon_3$

$d\bar{\varepsilon} = \sqrt{\frac{2}{3}(d\varepsilon_1^2 + 0^2 + (-d\varepsilon_1)^2} = \sqrt{\frac{2}{3}(2d\varepsilon_1^2)}$

$\sqrt{\frac{4}{3}d\varepsilon_1^2} = \boxed{\frac{2}{\sqrt{3}}|d\varepsilon_1|}$

b) $\bar{\sigma} = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}$

$\varepsilon_2 = 0, \quad \sigma_2' = \sigma_2 - \frac{\sigma_1 + \sigma_2 + \sigma_3}{3} = 0 \Rightarrow \sigma_2 = \frac{\sigma_1 + \sigma_3}{2}$

$\bar{\sigma} = \frac{1}{\sqrt{2}}\sqrt{\left(\sigma_1 - \frac{\sigma_1 + \sigma_3}{2}\right)^2 + \left(\frac{\sigma_1 + \sigma_3}{2} - \sigma_3\right)^2 + (\sigma_3 - \sigma_1)^2}$

$= \frac{1}{\sqrt{2}}\sqrt{\left(\frac{\sigma_1}{2} - \frac{\sigma_3}{2}\right)^2 + \left(\frac{\sigma_1}{2} + \frac{\sigma_3}{2}\right)^2 + \sigma_3^2 - 2\sigma_3\sigma_1 + \sigma_1^2}$

$= \frac{1}{\sqrt{2}}\sqrt{\frac{\sigma_1^2}{4} - \frac{\sigma_1\sigma_3}{2} + \frac{\sigma_3^2}{4} + \frac{\sigma_1^2}{4} + \frac{\sigma_1\sigma_3}{2} + \frac{\sigma_3^2}{4} + \sigma_3^2 - 2\sigma_3\sigma_1 + \sigma_1^2}$

$= \frac{1}{\sqrt{2}}\sqrt{\frac{3\sigma_1^2}{2} + \frac{3\sigma_3^2}{2} - 2\sigma_3\sigma_1}$

$= \frac{1}{\sqrt{2}}\sqrt{\frac{3}{2}(\sigma_1^2 - 2\sigma_3\sigma_1 + \sigma_3^2)} = \boxed{\frac{\sqrt{3}}{2}|\sigma_1 - \sigma_3|}$

c) $dW = (Y)(\text{answer to (a)})$

$\boxed{dW = (Y)\frac{2}{\sqrt{3}}|d\varepsilon_1|}$

10/10

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10

3. $E_v = 0.76 eV$

$$\frac{n_v}{n_{sites}} = Ce^{-E_v/kT}$$

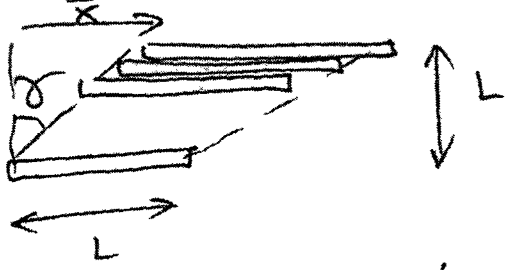
$$2.29\times10^{-5} = Ce^{-(0.76)/(86.2\times10^{-6})(673)}$$

$$C = 11.2035$$

$$\frac{n_v}{n_{sites}} = (11.2035)e^{-(0.76)/(86.2\times10^{-6})(933)}$$

$$= 8.82\times10^{-4}$$

4.




Consider N-dislocations at an average location $\bar{x}$ at time $t$.

The shear strain $\gamma$ is:

$$\gamma = \frac{Nb}{L}\frac{\bar{x}}{L} \quad \text{or}$$

$$\gamma = \frac{(NL)}{L^3}\, b\, \bar{x} \quad \text{or}$$

$$\gamma = \rho\, b\, \bar{x} \qquad (1)$$

5 points (if derived)

From (1) $\Rightarrow$ $\frac{\gamma}{t} = \rho b \frac{\bar{x}}{t}$

$\Downarrow$

5 points $\leftarrow$ $\boxed{\dot{\gamma} = \rho b \bar{v}}$

15/15

5. For BCC: $a = 4r/\sqrt{3} \Rightarrow r = a\sqrt{3}/4$

$|b|_{111} = 2r = a\sqrt{3}/2$

$|b|_{110} = \sqrt{2}a$

$$\frac{|b|_{110}^2}{|b|_{111}^2} = \frac{(\sqrt{2}a)^2}{(a\sqrt{3}/2)^2} = \frac{2a^2}{\frac{3a^2}{4}} = \frac{2}{3/4}$$

$= \boxed{2.67}$

6. $\cos\phi = \frac{(001)\cdot(111)}{(1)(\sqrt{3})} = \frac{1}{\sqrt{3}}$

$\cos\lambda = \frac{(001)\cdot(0\bar{1}1)}{(1)(\sqrt{2})} = \frac{1}{\sqrt{2}}$

$M = \cos\phi\cos\lambda = \left(\frac{1}{\sqrt{3}}\right)\left(\frac{1}{\sqrt{2}}\right) = \frac{1}{\sqrt{6}}$

$\tau = MY = \left(\frac{1}{\sqrt{6}}\right)(13.7\,MPa)$

$= \boxed{5.593\,MPa}$

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7. (a) proeutectic (Pb) = $\frac{61.9 - 40}{61.9 - 19.2}$ = 51.29%

liquid = 100 - 51.29 = 48.71%

(b) total (Pb) = $\frac{97.5 - 40}{97.5 - 19.2}$ = 73.44%

eutectic (Pb) = 73.44 - 51.29 = 22.15%

so, in 1 Kgr we have:

0.2215 Kgr eutectic (Pb)

0.5129 Kgr proeutectic (Pb)

1 - 0.7344 = 0.2656 Kgr (Sn)

15/15

8.

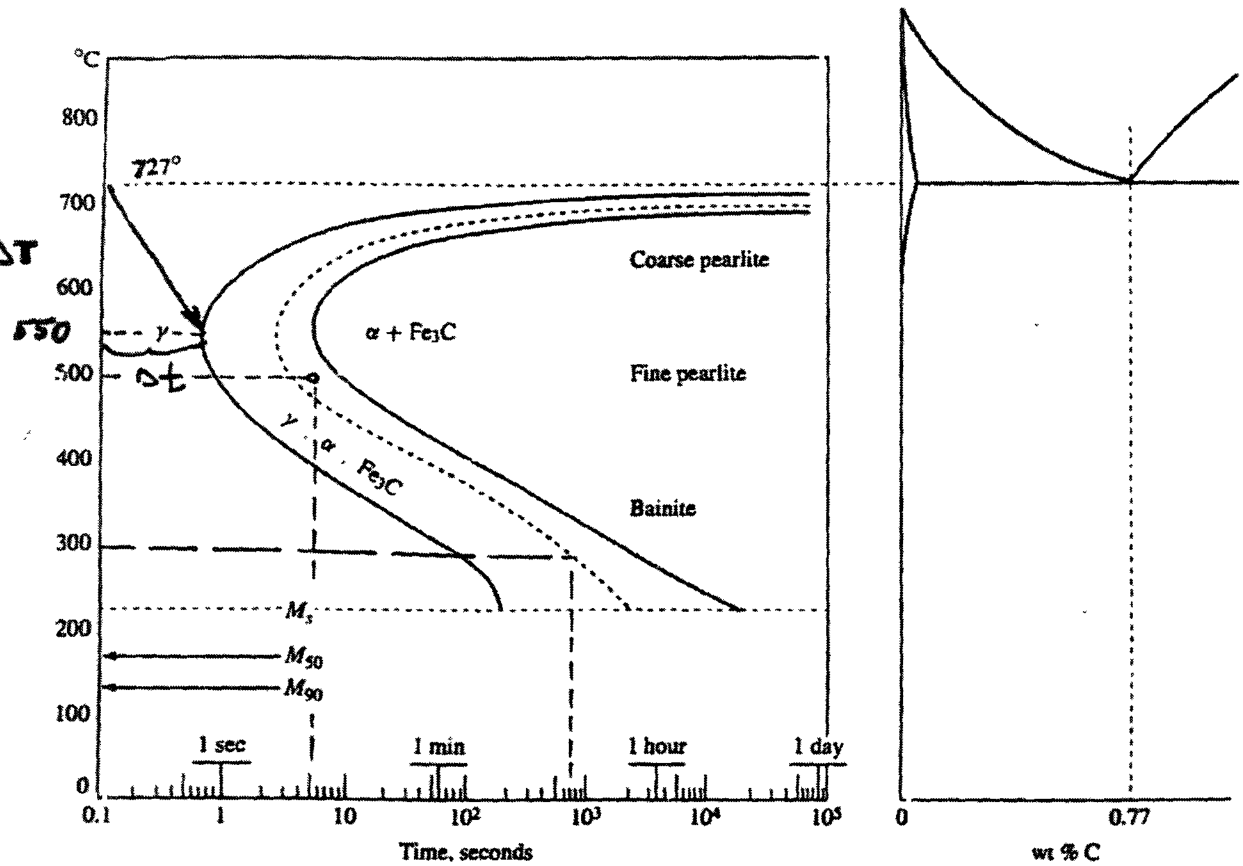
$$0.091 = \frac{6.69 - x}{6.69 - 0.02} - \frac{0.77 - x}{0.77 - 0.02}$$

$$0.091 = 1.003 - .149925x - 1.02667 + 1.3333x$$

$$1.18341x = 0.11467$$

$$\boxed{x = 0.096898\%}$$

9.




(a) $\frac{\Delta T}{t} = \frac{727 - 550}{0.7} \Rightarrow \frac{\Delta T}{t} = 250\ °C/sec$

(b) ~ 700 secs

(c) 70% fine-pearlite ($\alpha + Fe_3C$) +

~30% martensite +

a small percent of $\gamma$ (note that the martensitic transformation is complete at −46°C)