UES012: Engineering Materials
Tutorials Solutions

Tutorial 3-4

Question	Formula used	Answer
6.	*Linear density= no. of atoms / length*	(a) 2.77 atoms /nm (b) 3.912 atoms/nm (c) 1.597 atoms/nm
7.	*Linear density= no. of atoms / length*	$3.91*10^6$ atoms/mm
8.	*Linear density= no. of atoms / length*	[110]= 3.605 atoms/nm [111]= 1.47 atoms/nm
9.	$\rho_P = \frac{N_e}{A}$, where N_e is the no. of effective atoms in the plane and A is the area of the plane.	$[100] = \frac{3}{16r^2}$ $[110]= \frac{3}{8\sqrt{2}r^2}$ $[111]= = \frac{\sqrt{3}}{16r^2}$
10.	$\rho_P = \frac{N_e}{A}$	17.16×10^{12} atoms/mm^2
11.	$2d\ sin\theta = n\lambda$ $d = \frac{a}{\sqrt{h^2+k^2+l^2}}$	$a = 4.026$Å
12.	$2d\ sin\theta = n\lambda$ $d = \frac{a}{\sqrt{h^2+k^2+l^2}}$	$d = 2.227$ $\lambda = 1.5236$ Å
14.	$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$	d=5.63 Å
	$\rho = \frac{M}{V} = \frac{m \times N_e}{a^3}$ $m = \frac{atomic\ weight\ (m_A)}{Avagadro's\ number\ (N_A)}$	$a = 4.077$ Å
16.	APF= $\frac{Volume\ of\ atom\ in\ unit\ cell}{volume\ of\ unit\ cell}$	For SCC, APF= 0.57 For FCC, APF= 0.74
17.	$2d\ sin\theta = n\lambda$ $d = \frac{a}{\sqrt{h^2+k^2+l^2}}$ For FCC, $\sqrt{2}a = 4r$	$r = 1.45$ Å

UES012: Engineering Materials
Tutorials Solutions

Tutorial 5

Question	Formula used	Answer
1	For FCC, $a*\sqrt{2}=4R$ $\rho=\frac{A*n}{N*V}$	ρ=8.93g/cc
2	$h=\sqrt{3}a/2$ For HCP, Volume= $6*1/2*a*\sqrt{3}a/2*c$ $\rho=\frac{A*n}{N*V}$	ρ = 2.211 g/cc
3	For HCP, Volume= $6*1/2*a*\sqrt{3}a/2*c$ $\frac{c}{a}=\frac{\sqrt{8}}{\sqrt{3}}$ $\rho=\frac{A*n}{N*V}$	ρ=5.546 g/cc
4	$V_{BCC}= a^3/2$ (per atom) $V_{HCP}= a^3/6$ (per atom) %Change in volume = $\frac{VBCC-VHCP}{VBCC}$ x 100	%change in volume=3.2%
5	$V_{FCC}= a^3/4$ (per atom) $\sqrt{2}\,a = 4R$ $V_{BCC}= a^3/2$ (per atom) $\sqrt{3}\,a= 4R$ % change in volume at 990 °C= $\frac{\lvert V_{BCC}-V_{FCC}\rvert}{V_{BCC}}$ x 100 Linear change in iron= $\frac{\lvert a_{BCC}-a_{FCC}\rvert}{a_{BCC}}$ x 100	a_{FCC} = 3.671 Å a_{BCC} = 2.905 Å % change in volume at 990 °C =0.97% Linear change in iron= 26.36%
6.	APF= $\frac{Volume\ of\ atom\ in\ unit\ cell}{volume\ of\ unit\ cell}$	For HCP and FCC = 0.74 For SCC = 0.52 For BCC = 0.68
7.	$\frac{Rvoid}{Ratom}$ =0.414	R_{VOID} = 0.414*R_n
8.	Tetrahedral void at $(0,\frac{1}{2},\frac{1}{4})$ $\frac{RVOID}{RATOM}$ =0.225 Octahedral void at $(\frac{1}{2},\frac{1}{2},0)$ $(\frac{1}{2},0,0)$ $\frac{RVOID}{RATOM}$ =0.414	
9.	$\rho=\frac{A*n}{N*V}$ d= 2R	d=2.863 Å

UES012: Engineering Materials
Tutorials Solutions

Tutorial 6

Question	Formula used	Answer
1	R= 0.414r R= radius of largest interstitial void r = radius of iron atom	0.5341 Å
2	$No.\ of\ dislocations\ that\ have\ slipped\ out\ of\ the\ crystal = \frac{width\ of\ slip\ band - size\ of\ dislocations}{size\ of\ dislocations}$	999
5	$E = \frac{1}{2}\mu b^2$ $\rho = \frac{1}{l^2}$ $\tau = \frac{\mu b}{l} = \frac{\mu}{6}$	b = 1.67μm $E = 36.17 \times 10^{-3} J$
6	$n = N_A \exp\left(\frac{-\Delta H_F}{2RT}\right)$	$\frac{n_1}{n_2} = 1.31 \times 10^{-6}$
7	$\frac{b}{h} = \tan\theta$ $b = \frac{a}{\sqrt{2}}$	h =150.5 nÅ
8	$h = \frac{b}{\theta}$	$h_1 - h_2 = 107.48$ Å
9	$N_v = \frac{Affected\ area \times no.\ of\ atoms\ in\ unit\ cell}{area\ of\ the\ unit\ cell}$	1.73×10^{10}

UES012: Engineering Materials
Tutorials Solutions

Tutorial 7

Question	Formula used	Answer
3	$W_L = \frac{C_S - C_0}{C_S - C_L}$ $W_S = \frac{C_0 - C_L}{C_S - C_L}$	$W_L = 0.48$ $W_S = 0.52$
4	$P + F = C + 1$	Maximum no. of phases, $For\ F = 0,\ C = 2$, P=3 Maximum possible degree of freedom $For\ \ P = 1,\ C = 2$, F=2
5	$Y\ = \sigma + \frac{k}{\sqrt{d}}$	$Y\ = 178.61\ MPa$
6	Actual grain size $d = \sqrt{\frac{4 \times area\ of\ one\ grain}{\pi \times\ 10^4}}$ $Y\ = \sigma + \frac{k}{\sqrt{d}}$	Y_2-Y_1 = 292MPa
7	$Volume\ fraction\ of\ \alpha = \frac{V_\alpha}{V_\alpha + V_\beta}$ $Volume\ fraction\ of\ \beta = \frac{V_\beta}{V_\alpha + V_\beta}$	= 0.574 = 0.426
8	$weight\ fraction\ of Cu\ = \frac{W_{Cu}}{W_{Cu} + W_{Ni}}$ $weight\ fraction\ of\ Ni = \frac{W_{Ni}}{W_{Cu} + W_{Ni}}$	= 0.70 = 0.30

UES012: Engineering Materials
Tutorials Solutions
Tutorial 8-9

Question	Formula used	Answer
1(a)	Ideal density = (n x A)/$a^3.N_a$	11.35 g/cm^3
1 (b)	No. of vacancies = 4/(500 x (a^3 x 11.32))	5.83 x 10^{18}
1 (c)	Density= ((4-(4/500)) x 207.2)/((4.949 x 10^{-8})^3 x 6.022 x 10^{23})	11.32 g/cm^3
2	No of vacancy; n = N exp(-Q/k_B .T) and (N)= (N_a ρ)/A	3.65 x 10^{18} cm^{-3}
3	Q_v = -kT ln(n/N)	Q_v = 0.75 eV/atom
4	Schimid's law: $\tau = \sigma \cos\varphi_1 . \cos\varphi_2$	1225 psi
5	Hall-Petch eq. $\sigma_y = \sigma_0 + \frac{K}{\sqrt{d}}$	0.0148 mm
6	$\tau_R = \sigma \cos\varphi_1 . \cos\varphi_2$	22 MPa
7	$\tau = \sigma \cos\varphi_1 . \cos\varphi_2$	0.80 MPa or 114psi
8	$\sigma_T = F/A_f$	6.6 × 10^8 N/m^2 or 660 MPa
9	F = (δd× π d0 ×E)/4 v	*5600 N*
10	a) $\sigma_y = F_{max}/A$; $F_{max} = \sigma_y \times A$	89375 N
	b) Max. length = $l_0+\delta l = l_0 + (\sigma_y \times l_0)/E$	115.28 mm
11	$\sigma = F/A_0 = F/\pi(d_0^2/4) = E\times(\delta l/l_0)$	7.65×10^{-3} m or 7.65 mm
12 (a)	$\varphi_1 = \cos^{-1}[\frac{(u_1u_2+v_1v_2+w_1w_2)}{\sqrt{(u1^2+v1^2+w1^2)(u2^2+v2^2+w2^2)}}]$	0 MPa
(b)	The most favored slip system is the one that has the largest τ_R value. Therefore, the (110)-[-111] is the most favored since its τ_R (1.12 MPa) is greater than the τ_R value for (101)-[-111]	(viz., 0 Mpa)