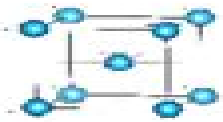
Atomic bonding

Ionic: Anions gain electrons, cations lose electrons
Covalent: electrons shared between two atoms
Metallic: electrons shared between many atoms
Van der Waals: temporary or permanent dipole
Interacts with other objects

Crystal structures

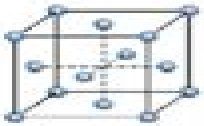
BODY CENTERED CUBIC

$4R = \sqrt{a^2 + a^2 + a^2}$
$4R = a\sqrt{3}$
1 center atom, 8 corner atoms
2 atoms per unit cell



FACE CENTERED CUBIC

$4R = \sqrt{a^2 + a^2}$
$4R = a\sqrt{2}$
6 face atoms, 8 corner atoms
4 atoms per unit cell



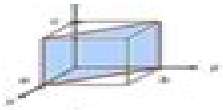
Volume of a cubic $= a^3$
$\mathring{A} = 10^{-10}\,m$

$$\text{Avogadro No} = 6.022 * 10^{23}\left(\frac{atoms}{mol}\right)$$

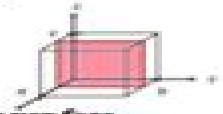
$$Density = \frac{mass}{volume} = \frac{\#\ of\ atoms \times atomic\ mass}{volume\ of\ unit\ cell * Avogadro}$$

Miller Indices

example	x	y	z
1. Intercepts	1	1	∞
2. Reciprocals	1/1	1/1	1/∞
3. Reduction	1	1	0
4. Miller Indices	(110)		



example	x	y	z
1. Intercepts	1/2	∞	∞
2. Reciprocals	1/½	1/∞	1/∞
3. Reduction	2	0	0
4. Miller Indices	(200)		



$$Planar\ Density = \frac{\text{atoms per face}}{\text{area of face}}$$

$$Packing\ Factor = \frac{\text{volume of atom} \times \text{number of } \frac{atoms}{cell}}{\text{volume of the unit cell}}$$

Point Defects

$n_v = n * e^{-\frac{Q_v}{RT}}$
$n_v = \#\frac{vacancies}{cm^3}, n = \#\frac{atoms}{cm^3},$
$Q_v = energy\ for\ 1\ mol\ of\ vacancies, T = Temp$
$R = Gas\ constant = 1.987\frac{cal}{molK} = 8.314\frac{joules}{molk}$

Diffusion

$D = D_o * e^{-\frac{Q}{RT}}$
$D_o = constant\ based\ on\ material$
$Q_v = energy\ for\ 1\ mol\ of\ vacancies, T = Temp$
$R = Gas\ constant = 1.987\frac{cal}{mol * K} = 8.314\frac{joules}{mol * K}$

$J = -D * \frac{dc}{dx}, x = thickness, J = Flux$ - **Fick's 1st law**
$c = Compositions\ in\ atomic\ percent$

Mechanical Properties

$Engineering\ stress\ (S) = \frac{F}{A_o}$
$Engineering\ Strain\ (e) = \frac{\Delta l}{l}$
$Young\ Modulus\ (E) = \frac{S}{e}$
$F = Force, A_o = Area$
$\Delta l = Change\ in\ length, l = Original\ length$
$K_c\ or\ K_{ic} = f\sigma\sqrt{\pi a}$
$\sigma = Exposed\ stress, a = flaw\ size$
$f = geometry\ factor\ for\ the\ specimen\ and\ flaw$
$K_c = fracture\ toughness$
$K_{ic} = plain\ strain\ fracture\ toughness$
$\pm\sigma = 5.09 * \frac{FL}{d^3}$
F = Applied Load, L = Length of shaft
d = diameter of shaft

$$1 - F(V) = \exp\left[-\left(\frac{\sigma}{\sigma_o}\right)^m\right]$$

m = Weibull Modulus, σ = Flexural Strength
F = Failure, σ_o = Initial Flexural Strength

$$\text{Poissons Ratio } (\nu) = \frac{-\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$$

$$\text{Modulus of resilience } (E_r) = \frac{1}{2}(\text{yield strength})(\text{strain@yielding})$$

$$\text{Ductility \%Elongation} = \frac{l_f - l_o}{l_o} * 100\%$$

$$Ductility\ \%Reduction\ in\ area = \frac{A_o - A_f}{A_o} * 100\%$$

$$True\ Stress = \frac{F}{A_f}$$

$$True\ Strain = \ln\left(\frac{l}{l_o}\right)$$

$\sigma_t = K\varepsilon_t^n$
n = strain coefficient, K = Constant,
ε_t = True strain, σ_t = True Stress

$\sigma_m = 2\sigma_o\left(\frac{a}{r_c}\right)^{\frac{1}{2}}$
σ_m = Stress @ Crack tip, σ_o = Applied stress
a = Crack Length, r_c = radius of curvature

$\sigma_c = \left(\frac{2E\gamma_s}{a\pi}\right)^{\frac{1}{2}}$
σ_c = Critical Stress, E = elastic modulus
γ_s = specific surface energy
α = one half length of internal crack

Solidification and Nucleation

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Annelies Wilder-Smith

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