MSEG201 LQ1 formula sheet

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$k = 1.38 \times 10^{-23}$ J/atom · K
$k = 8.62 \times 10^{-5}$ eV/atom · K
$N_A = 6.022 \times 10^{23}$ atoms/mol

$R = 8.314$ J/mol · K
$e = 1.6 \times 10^{-19}$ C
$m_e = 9.11 \times 10^{-31}$ kg

$m_p = 1.67 \times 10^{-27}$ kg
$m_n = 1.67 \times 10^{-27}$ kg
$\lambda_{Cu_{K-\alpha}} = 1.54$ Å

Prefix	Symbol	Factor	Prefix	Symbol	Factor
pico	p	10^{-12}	milli	m	10^{-3}
angstrom	Å	10^{-10}	centi	c	10^{-2}
nano	n	10^{-9}	deci	d	10^{-1}
micro	μ	10^{-6}			

System	coordination	APF	atoms	r a relationship	close packed	reflection rule	plane ex
FCC	12	0.74	4	$4r = \sqrt{2}a$	face diagonal	h,k,l all even or odd	(111), (200)
BCC	8	0.68	2	$4r = \sqrt{3}a$	body diagonal	h+k+l = 2n	(111), (200), (220)
SC	6	0.52	1	$2r = a$	edge	all	all!
HCP	12	0.74	2	$2r = a$; $c = \sqrt{\frac{8}{3}}a$	base edge		

System	interstitial sites
FCC	octahedral edges; mid diagonals tetrahedral
BCC	octahedral edge centers & face centers; tetrahedral face diamonds

r_{cat}/r_{an}	coordination	structure	example	formula units/cell
< 0.155	2	linear		2
0.155 - 0.225	3	trigonal planar		3
0.225 - 0.414	4	tetrahedral	zincblende	4
0.414 - 0.732	6	octahedral	rock salt; NaCl	4
0.732 - 1.0	8	cubic	CsCl	1
AX_2	8	flourite/antiflourite	CaF_2	4

notation: (hkl) is a plane, [uvw] is a direction, {hkl} is a family of planes

cubics

$$\rho = \frac{n \cdot A}{V \cdot N_A}$$

ceramics

$$\rho = \frac{n\left(\sum A_c + \sum A_a\right)}{V \cdot N_A}$$

metals

$$\frac{N_v}{N} = \exp\left(\frac{-Q_v}{kT}\right)$$

ceramics

$$\frac{N_s}{N} = \exp\left(\frac{-Q_s}{2kT}\right)$$

$$N = \rho \cdot \frac{N_A}{\mu}$$

$$n\lambda = 2d\sin(\theta)$$

$$d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

$$\ln\left(\frac{N_{v2}}{N_{v1}}\right) = \frac{-Q_v}{k}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$E = E_A + E_R$$

$$E_A = -\frac{A}{r}$$

$$E_R = \frac{B}{r^n}$$

equlateral triangle: $A = \frac{\sqrt{3}}{4}a^2$
volume of a sphere: $V = \frac{4}{3}\pi r^3$
area of a circle: $A = \pi r^2$
volume of a cylinder: $V = \pi r^2 h$

volume of a cone: $V = \frac{1}{3}\pi r^2 h$
volume of a pyramid: $V = \frac{1}{3}A_b h$
volume of a tetrahedron: $V = \frac{1}{6}\sqrt{2}a^3$

volume of a cube: $V = a^3$
circle circumference: $C = 2\pi r$
triangle area: $A = \frac{1}{2}bh$
pythagorean: $a^2 + b^2 = c^2$

30-60-90: $a, a\sqrt{3}, 2a$
45-45-90: $a, a, a\sqrt{2}$
1 radian: 57.3°
1 degree: $\frac{\pi}{180}$ radians

solid solutions

- $\Delta r < 15\%$ (similar atomic radii)
- as ΔEN decreases, solubility increases
- same structure (i.e. both FCC)
- a metal dissolves better in higher valency host

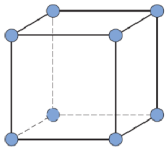
Defects

- vacancies–absence of atom, distorts planes
- dislocations–line defect, edge or screw
- frenkel–cation vacancy + cation interstitial
- shottky–cation and anion vacancy
- edge dislocation–extra half plane of atoms
- bergers vector–direction and magnitude of dislocation
- screw dislocation–spiral planar defect

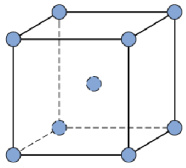
Grains

- grain boundary–interface between grains
- angle boundary–interface between grains with different orientations
- high angle boundaries leads to higher surface energy
- smaller grains have higher surface energy
- anisotropy–directional dependence of properties

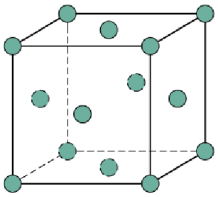
Simple Cubic (SC)



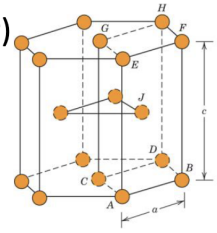
Body-Centered (BCC)



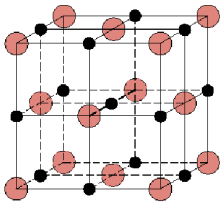
Face-Centered (FCC)



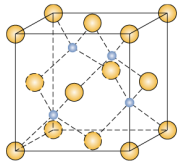
Hexagonal close packed (HCP)



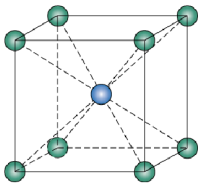
Rock Salt (AX)



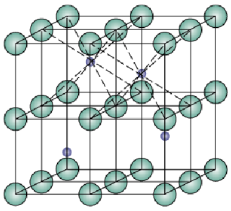
Zincblende (AX)

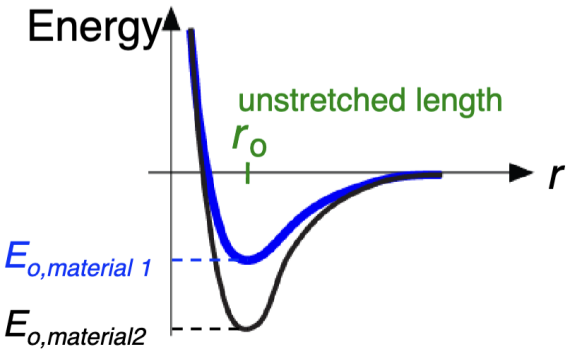


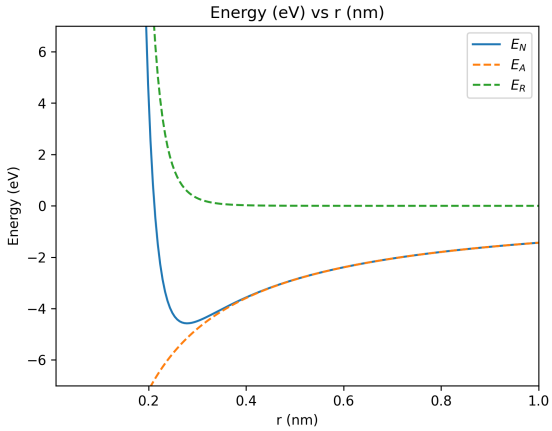
Cesium Chloride (AX)



Fluorite/Anti-Fluorite (AX_2)







Larger E_0	Larger T_m
Smaller E_0	Larger α