ME254: Materials Engineering Homework 4 Due: Monday, October 27, 2014

1st semester 1435-1436 H Instructor: Dr. Hamad F. Alharbi

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1. Give brief explanations about the point, line, and planar defects exist in crystalline solids? Provide schematic sketch for each type as possible.
***Solution**: See the book/slides.*

2. Briefly explain the difference between substitutional and interstitial solution solutions?
***Solution**: See the book/slides.*

3. Calculate the activation energy for vacancy formation in aluminum, given that the equilibrium number of vacancies at 500°C (773 K) is 7.55×10^{23} m^{-3}. The atomic weight and density (at 500°C) for aluminum are, respectively, 26.98 g/mol and 2.62 g/cm^3. Boltzman constant k= 8.62e-5 (eV/atom K)

Solution:

% Given:
Nv=8.47e23 m^{-3}
T=500+273 K
A=26.98 g/mol
density=2.17 g/cm^3
k=8.62e-5 eV/atom K (Boltzman constant)

% Mass in m^3
mass=density*1e6;

% Number of atoms per m^3

$$N = \frac{N_A \rho_{Al}}{A_{Al}}$$

= 6.022e23*mass/A = 4 .8435e+28 atoms/m^3

% Activation energy

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

$$\ln N_v = \ln N - \frac{Q_v}{kT}$$

$$Q_v = -kT \ln\left(\frac{N_v}{N}\right) = 0.7299 \text{ eV/atom}$$

4. What is the composition, in weight percent and atom percent, of an alloy that contains 35.7 kg copper, 41.9 kg zinc, and 4.95 kg lead?

Solution:

% Given:
m_Cu=35.7e3; % g
A_Cu=63.55; %g/mol

m_Zn=41.9e3; % g
A_Zn=65.41; %g/mol

m_Pb=4.95e3; % g
A_Pb=207.2; %g/mol
% ==========
% Calcualte Composition in Wt%

% Total mass
Mass_All=m_Cu+m_Zn+m_Pb = 82550

% Wt% of xx
WtPercent_Cu=m_Cu/Mass_All * 100 = 43.2465 Wt%
WtPercent_Zn=m_Zn/Mass_All * 100 = 50.7571 Wt%
WtPercent_Pb=m_Pb/Mass_All * 100 = 5.9964 Wt%
% ==========
% Calcualte Composition in At%

% Number of moles
Nmole_Cu=m_Cu/A_Cu = 561.7624
Nmole_Zn=m_Zn/A_Zn = 640.5748
Nmole_Pb=m_Pb/A_Pb = 23.8900

% Total number of moles
Nmole_All= Nmole_Cu+Nmole_Zn+Nmole_Pb = 1226.2

% At% of xx
AtomPercent_Cu=Nmole_Cu/Nmole_All * 100 = 45.812 at%
AtomPercent_Zn=Nmole_Zn/Nmole_All * 100 = 52.239 at%
AtomPercent_Pb=Nmole_Pb/Nmole_All * 100 = 1.9482 at%

5. Copper forms a solid solution with zinc. If the concentration of copper in a copper-zinc alloy is 41.9 at% and the mass of zinc is 47 g, compute the number of atoms of copper in this alloy? The atomic weight of zinc is 65.39 g/mole. $N_{av} = 6.023\ x\ 10^{23}$

Solution:

Calculate the number of moles of zinc in the alloy:

$$N_{mol-zn} = \frac{M}{A} = \frac{47\ (g)}{65.39\ (\frac{g}{mole})} = 0.7187\ mol$$

$$C_{cu} = 0.419 = \frac{N_{mol-cu}}{N_{mol-cu} + N_{mol-zn}}$$

$$\Rightarrow N_{mol-cu} = \frac{0.419}{0.581} N_{mol-zn} = 0.721 * 0.7187 = 0.5182\ mol$$

The number of atoms of copper:

$$N_{atom-cu} = N_{av} * N_{mol-cu} = 6.023\ x\ 10^{23} \left(\frac{atoms}{mole}\right) * 0.5182$$
$$= 3.121\ x\ 10^{23}\ atoms$$