Problem 1
Rhodium has an atomic radius of 0.1345 nm, a density of 12.41 gm/cm^3 and atomic weight, A_{Rh} = 102.91 gm/mole. Determine if the structure is BCC or FCC.

$r = 0.1345$ nm $\quad \rho = 12.41$ gm/cm^3 $\quad A_w = 102.91$ gm/mole

$$\rho = \frac{nA_w}{V_c N_A}$$

$$V_{c_{BCC}} = a_{BCC}^3 = \left(\frac{4r}{\sqrt{3}}\right)^3 \qquad n_{BCC} = 2$$

$$V_{c_{FCC}} = a_{FCC}^3 = (2r\sqrt{2})^3 \qquad n_{FCC} = 4$$

For FCC

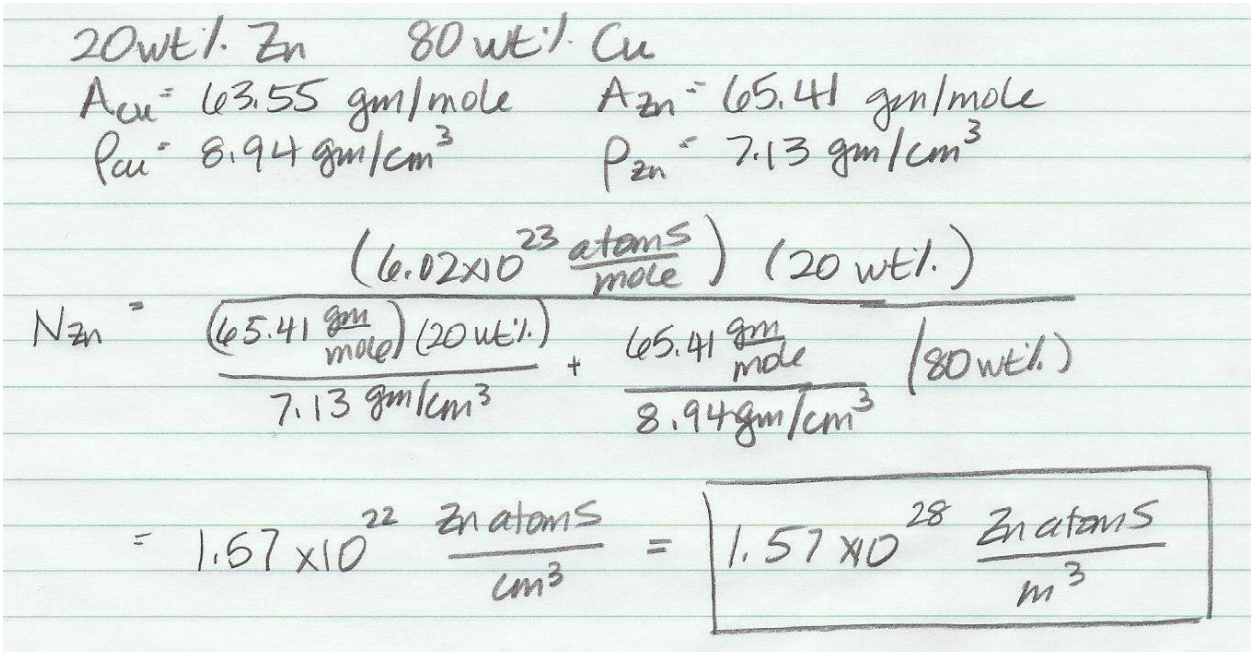
$$\rho = \frac{4(102.91 \text{ gm/mole})}{(2 \times 0.1345 \times 10^{-7} \text{ cm} \sqrt{2})^3 \cdot 6.02 \times 10^{23} \frac{\text{atoms}}{\text{mole}}} = 12.42 \frac{\text{gm}}{\text{cm}^3}$$

For BCC

$$\rho = \frac{2(102.91 \text{ gm/mole})}{\left(\frac{4 \times 0.1345 \times 10^{-7} \text{cm}}{\sqrt{3}}\right)^3 \cdot 6.02 \times 10^{23} \frac{\text{atoms}}{\text{mole}}} = 11.41 \frac{\text{gm}}{\text{cm}^3}$$

Then it is **FCC**

Problem 2
An alloy contains 20 wt.% zinc and 80 wt.% copper. What is the concentration of Zn (in atoms of Zn/m^3) in the alloy?
DATA: A_{Cu} = 63.55 gm/mole, A_{Zn} = 65.41 gm/mole, ρ_{Cu} = 8.94 gm/cm^3, ρ_{Zn} = 7.13 gm/cm^3



Problem 3
The fraction of vacancies in a metal at 1000˚C is 5.32 x 10^{-5}. What is the fraction of vacancies at 1200˚C?

$n_V = \exp\left(\frac{-Q_V}{kT}\right)$

At $1000°C = 1273K$ $\quad n_V = \exp\left(\frac{-Q_V}{8.62\times10^{-5}\ \frac{eV}{atom\,K}\cdot 1273K}\right)$

$= 5.32\times10^{-5}$

$\Rightarrow Q_V = 1.08\ eV$

At $1200°C = 1473K$ $\quad n_V = \left(\frac{-1.08}{8.62\times10^{-5}\cdot 1473}\right) = \boxed{2.02\times10^{-4}}$

Problem 4

Nitrogen from a gaseous phase is to be diffused into pure iron. If the surface concentration is maintained at 0.1 wt.% N, what will be the concentration at 1 mm from the surface after 10 hours? The diffusion coefficient for N in Fe is 2.5×10^{-11} m^2/sec.

Tabulation of Error Function Values

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

$T = 700°C = 973\ K$

$C_s = 0.1$ wt% N $C_0 = 0$ $C_x = ?$ $x = 10^{-3}$ m $t = 10$ hrs

$D = 2.5 \times 10^{-11}$ m^2/sec

$$\frac{C_x - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

$$\frac{C_x}{0.1} = 1 - erf\left[\frac{10^{-3}\ m}{2\sqrt{2.5\times10^{-11}\ \frac{m^2}{sec} \times 10\ hrs \times 3600\ \frac{sec}{hr}}}\right]$$

$$\frac{C_x}{0.1} = 1 - erf(0.53)$$

From table

z	$erf(z)$
0.5	0.5205
0.53	x
0.55	0.5633

$$\frac{C_x}{0.1} = 1 - 0.55$$

Interpolate:

$$\frac{x - 0.5205}{0.53 - 0.5} = \frac{0.5633 - 0.5205}{0.55 - 0.5}$$

$$x = 0.55 - erf(0.53)$$

$$\Rightarrow \boxed{C_x = 0.045 \text{ wt\% N}}$$

Problem 5
Put your answer in the boxes to the right.

	(answer)
A close packed plane in the BCC structure is the: (a) (111) (b) (001) (c) $(1\bar{1}0)$ (d) none of the above	c
An ionic bond forms by the: (a) formation of an electron cloud surrounding the atoms (b) sharing of electrons between the atoms (c) transfer of an electron from one atom to the other (d) none of the above	d
An x-ray diffraction pattern from a FCC crystal has a peak at $2\theta = 40^\circ$ that is indexed to the (200) plane. What is the lattice parameter? The x-ray wavelength = 0.154 nm. (a) 0.450 nm (b) 0.120 nm (c) 0.239 nm (d) none of the above	a
T/F Steady state diffusion occurs when the concentration gradient is fixed.	T
The grain size of a material can be determined by: (a) x-ray diffraction (b) optical microscopy (c) the density (d) all of the above	b

$$2d_{hjl}\sin\theta_{hkl} = n\lambda \qquad n = 1$$

$$d_{hjl} = \frac{a}{\sqrt{h^2 + k^2 + \ell^2}}$$

$$\frac{2a}{\sqrt{2^2}}\sin(20^\circ) = 0.154\ nm$$

$$a = 0.450\ nm$$