MAE 20
Example Midterm 1

Closed book and notes

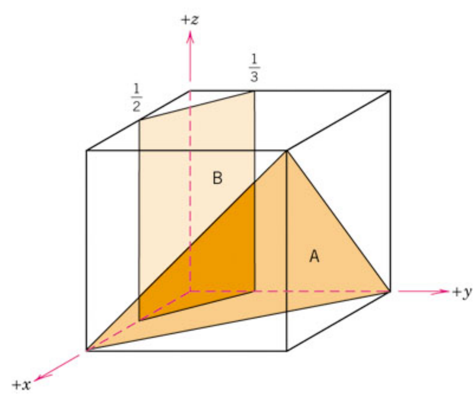
All questions worth 10 points

1. A BCC iron metal foil is 25 μm thick. Assume that all of the unit cells are arranged so that a_o is perpendicular to the foil surface. For a 1 cm x 1 cm piece of foil, calculate:
   (a) the thickness of the foil in number of unit cells
   (b) total number of unit cells in the piece of foil
   DATA: r_{Fe} = 0.124 nm

2. A steel bar is placed in a furnace and carbon is allowed to diffuse into the material. What is the temperature (˚C) required to obtain 0.50% C at a distance of 0.5 mm beneath the surface of a 0.20% C steel in 5 hours when 0.71% C is present at the surface at all time?
   DATA: For the diffusion coefficient, D_o = 0.23 cm^2/sec and Q = 134 kJ/mole
   R = gas constant = 8.314 J/mole•K

3. The fraction of vacant lattice sites in aluminum at 650˚C is 10^{-3}. What is the energy required to create vacancies in aluminum?

4. Determine the Miller indices for the planes in the unit cell shown below.



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

	(answer)
A close packed plane in the fcc structure is the: (a) (110) (b) (001) (c) (111) (d) none of the above	
The major types of atomic bonds are: (a) metallic, covalent, ionic (b) van der Waals, covalent, metallic (c) hydrogen, ionic, metallic (d) none of the above	
From the energy as a function of atomic separation diagram, the equilibrium separation distance between two atoms is: (a) when E = 0 (b) when E is the minimum value (c) when E is the maximum value (d) none of the above	
T/F Non-steady state diffusion occurs when one end of a semi-infinite rod is held at a constant surface composition.	
A x-ray diffraction pattern taken from an unknown solid with a cubic crystal structure can be used to determine: (a) the composition of the solid (b) the density of the solid (c) the lattice parameter, a (d) all of the above	

$$N_A = 6.02 \times 10^{23}\, atoms\,/\,mole$$

$$R = 8.314\ J\,/\,mole \bullet K$$

$$k = 8.62 \times 10^{-5}\, eV\,/\,atom \bullet K$$

$$K = 273 + ^{\circ}C$$

$$E = \int F dr$$

$$E_N = -\frac{A}{r} + \frac{B}{r^n} = E_{att.} + E_{rep}$$

$$APF = \frac{V_S}{V_C}$$

$$a = 2R\sqrt{2}$$

$$a = 4R\,/\,\sqrt{3}$$

$$N = \frac{\rho N_A}{A}$$

$$\rho = \frac{nA}{V_C N_A}$$

$$LD = \frac{number\ of\ atoms}{length}$$

$$PD = \frac{number\ of\ atoms}{area}$$

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

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

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

$$C_1 = \frac{m_1}{m_1 + m_2} \times 100$$

$$C_1 + C_2 = 100$$

$$n_{m_1} = \frac{m_1'}{A_1}$$

$$C_1' = \frac{n_{m_1}}{n_{m_1} + n_{m_2}} \times 100$$

$$C_2' = \frac{n_{m_2}}{n_{m_1} + n_{m_2}} \times 100$$

$$C_1' = \frac{C_1 A_2}{C_1 A_2 + C_2 A_1} \times 100$$

$$C_2' = \frac{C_2 A_1}{C_1 A_2 + C_2 A_1} \times 100$$

$$C_1 = \frac{C_1' A_1}{C_1' A_1 + C_2' A_2} \times 100$$

$$C_2 = \frac{C_2' A_2}{C_1' A_1 + C_2' A_2} \times 100$$

$$C_1'' = \left(\frac{C_1}{\frac{C_1}{\rho_1} + \frac{C_2}{\rho_2}}\right) x10^3$$

$$C_2'' = \left(\frac{C_2}{\frac{C_1}{\rho_1} + \frac{C_2}{\rho_2}}\right) x10^3$$

$$\rho_{ave} = \frac{100}{\frac{C_1}{\rho_1} + \frac{C_2}{\rho_2}}$$

$$\rho_{ave} = \frac{C_1' A_1 + C_2' A_2}{\frac{C_1' A_1}{\rho_1} + \frac{C_2' A_2}{\rho_2}}$$

$$A_{ave} = \frac{100}{\frac{C_1}{A_1} + \frac{C_2}{A_2}}$$

$$A_{ave} = \frac{C_1' A_1 + C_2' A_2}{100}$$

$$N_1 = \frac{N_A C_1}{\frac{C_1 A_1}{\rho_1} + \frac{A_1}{\rho_2}\left(100 - C_1\right)}$$

$$N = 2^n - 1$$

$$J = -D\frac{dC}{dx}$$

$$D = D_o \exp\left(\frac{-Q_d}{RT}\right)$$

$$\frac{\partial C}{dt} = D\frac{\partial^2 C}{\partial x^2}$$

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