ENGG 201 – Winter 2013 - Chapter 3 Examples and Problems

Winter 2007 Final Exam

Question Number V *(15 Marks ~ 27 minutes)*
Iron atoms (M= 55.85 kg/kmol, molecular diameter = 2.5 Å) are arranged in a face-centered cubic lattice (FCC) above 1180 K, and a different structure below 1180 K (density below 1180K =7.71 g/cm^3).

i. Calculate the density of iron above 1180 K. *(/2)*
ii. What is the length of a side of the unit cell above 1180 K? *(/1)*
iii. Determine the structure of iron below 1180 K. *(/2)*
iv. What would be the change in length for a cubic block of iron with a mass of 1000 kg transitioning from below 1180 to above 1180 K? *(/2)*

Question Number VI *(Continued)*
Nitrogen freezes at -210°C, and the Lennard Jones parameters for nitrogen are ε/k=96.3 K and b_o=0.0636 m^3/kmol.

i) Determine the separation distance where the potential energy between two nitrogen molecules will be a minimum. *(/2)*
ii) What are the values of the potential energy and the force between 2 nitrogen molecules at the distance in i)? *(/2)*
iii) What is the value of the force between two nitrogen molecules at a separation distance equal to 2.5x the minimum potential energy distance? *(/4)*

Winter 2008 Final Exam

Question Number V *(13 Marks ~ 23 minutes)*
Aluminum (M=26.98 kg/kmol, = 2.62 Å) is known to exist in an FCC structure at 25°C and 1 atm, has a ~~Young's modulus 69 GPa, Poisson's ratio 0.33~~, coefficient of thermal expansion 22.68x10^{-6} K^{-1}, and thermal conductivity 190 W/mK.

a) For a solid sphere of metallic aluminum at 25°C and 1 atm with a volume of 10^{-3} cm^3, calculate values of the following quantities:
   i. The specific volume of aluminum (m^3/kg) (/2)
   ii. The mass of the sphere. (/1)
   iii. The total volume of void space in the sphere. (/2)

Winter 2009 Final Exam

Question Number V *(15 Marks ~ 27 minutes)*
PART 1: You have been asked to design a system to pack oranges into boxes. Each orange can be thought of as a rigid 8 cm diameter sphere with density 900 kg/m^3. If the oranges are packed with a simple cubic pattern, then 350 can fit in a box (5 wide, 10 deep, and 7 high). That's a lot of oranges.

a) Calculate the fraction of empty space in the box when the oranges are packed in a simple cubic arrangement. Show your work. *(/2)*
b) Determine the mass of oranges in a box when the oranges are packed in a simple cubic arrangement. *(/1)*
c) Determine the effective density of the orange-filled box. The empty box weighs 2 kg. *(/2)*

d) Using the limit of an infinitely large box, what percentage more oranges can fit in a box if the arrangement is face-centered cubic packing compared to simple cubic packing? ***(/2)***

Question Number VI *(Continued)*

PART 2: Use the parameters below to answer the following questions:

	M, kg/kmol	**£/k, K**	**±Å**
Oxygen	32	154	2.33
Nitrogen	28	78	2.94

a) Assuming ideal gas behavior, calculate the diffusivity of nitrogen gas at 50°C and 3 atm. *(/2)*
b) Assuming ideal gas behavior, calculate the value of the Prandtl number ($C_p\mu/k$) for nitrogen at 50°C and 3 atm. *(/2)*
c) Determine the net force between two molecules of oxygen separated by a distance of 3 times the minimum potential distance. *(/2)*
d) What is the minimum potential energy that occurs between two molecules of oxygen? *(/2)*

Winter 2010 Final Exam

Question Number V *(15 Marks ~ 27 minutes)*

PART 1:

The density of silver (M = 107.88 g/mol) at 20°C is 10520 kg/m^3, and the closest interatomic distance is 2.888 Angstroms.

a) Determine the structure of silver at 20°C. (/2)
b) A 10 kg bar of silver is 4 cm wide by 4 cm high. Estimate the length of the bar at 20°C. (/3)
c) Calculate the fraction of void space in the bar of silver at 20°C. (/2)

Question Number VI *(15 Marks ~ 36 minutes)*

PART 1:

The Lennard-Jones parameters for a substance (M=28) are: $\varepsilon=133\times10^{-23}$J, $b_o=0.064$m^3/kmol.

a) Calculate the separation distance at which the net force between two adjacent molecules is zero. (/2)
b) What is the potential energy between two adjacent molecules when the net force is zero? (/2)
c) Calculate the net force between two adjacent molecules when the separation distance is 3 times the molecular diameter. (/3)