ORDRE DES INGÉNIEURS DU QUÉBEC

FALL 2015 SESSION

Open-book examination
Calculators: only authorized models
Duration: 3 hours

Structure of Materials
14-MT-A4

Note : the exam is on 81 points, and will be converted to 100 points.

Please, answer all questions.

Question 1. (2 points)
What is the angle between the [100] and [111] directions in the cubic system?

Question 2. (4 points)
A 1.25-cm-diameter bar is subjected to a load of 2,500kg. Calculate the engineering stress on the bar in MPa.

Question 3. (4 points)
What are the four Hume-Rothery rules for the solid solubility of one element in another?

Question 4. (4 points)
Calculate the radius of the largest interstitial void in the FCC gamma iron lattice. The atomic radius of the iron atom is 0.129nm in the FCC lattice, and the largest interstitial voids occur at the (½ 0 0), (0 ½ 0), (0 0 ½), etc type positions.

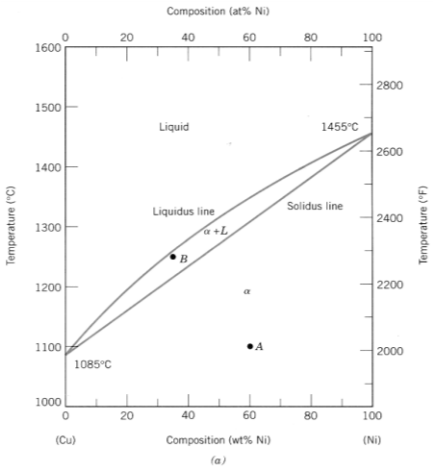
Question 5. (5 + 2 points)
Name five components that are manufactured by the casting process? Why is casting so popular?

Question 6. (4 points)
Calculate the planar atomic density on the (120) plane of the Cu FCC lattice in atoms per square millimeter. The lattice constant is 0.361nm.

Question 7. (5+5+5 points)
a) Describe and draw the microstructure evolution during the solidification of a Cu-20Ni alloy.

b) Describe and draw the microstructure evolution during quench solidification of a Cu-20Ni alloy.

c) Would it be correct to assume that an atomic mixture 50-50 would be the alloy with maximal strength? Justify your statement with scientific reasoning and/or calculation.



Question 8. (10 points)
For two elements, A and B, that are ionically bonded, the attractive and repulsive energies EA and ER (in electron volts per A-B pair) depend on the distance (r in nanometers) between the two resulting ions, as follows:

$$E_A = \frac{-1.43}{r} \quad \text{et} \quad E_R = \frac{6.73 \cdot 10^{-6}}{r^8}$$

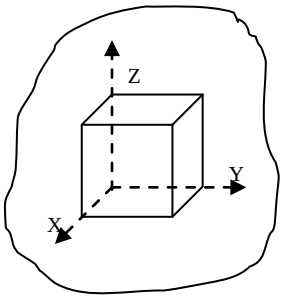
Determine the equilibrium distance for the two elements and the force required to break the bond.
$1eV = 1.6X10^{-19}$ J

Question 9. (3 points)
Draw and explain the engineering stress-strain curves, including the critical features.

Question 10. (2 points)
After forming an ionic bond, why is the sodium ion smaller than the sodium atom?

Question 11. (10 points)
If it takes $9x10^3$ minutes to recrystallize a piece of copper at 88C, and 200 minutes at 135C, what is the activation energy for the process, assuming the process obeys the Arrhenius rate equation and the time to recrystallize = $Ce^{+Q/RT}$, where R: 8.3144 J/(mol*K) and T is in kelvins?

Question 12. (10 points)
Calculate the stress to be applied on the [001] direction of a nickel FCC unit cell to active the (111) [0 -1 1] slip system. The critical resolve shear stress of Ni is 5.6 MPa.



Question 13. (6 points)
Complete the following table.

Definition	Answer
A heat treatment given to a metal to soften it.	
An ion with a negative charge.	
The ability of a metal to exist in two or more crystal structures.	
The process of atom moving over each other during the permanent deformation of a metal.	
The process whereby a cold-worked metal is heated to a sufficiently high temperature for a long enough time to form a new strain-free grain structure.	
A convenient repeating unit of a space lattice.	