Homework #5

Spring 2016

Due date: May 3rd in class (hard copy print out).

ECE 6307 – Nanomaterials and Solar Energy, CHEE6320 -Introduction Nanomaterials Engineering, MTLS6320 - Nanomaterials Engineering, CHEE5320 – Introduction to Nanomaterials Engineering ECE5320 - Introduction to Nanomaterials Engineering, MECE5320- Introduction to Nanomaterials Engineering,

Student Name _____

Student ID _____

Instructions: The first page of this HW assignment has to be incorporated into your material HW. Make sure this page is signed and has your information. Students, your work (hard copy) has to be handed to the instructor at the indicated due date. Make sure your HW is typed in MS work or similar software. Handwritten submission will not be accepted. Exceptions applies to sketches that should be explanatory to your derivations or problem posting. Only independent work will be granted points. Work in the group, consulting among the students, or other type of collaboration is strictly forbidden. Student who violate this rule will be subject to the college academic honesty hearing. Problems with * marking indicate also the question that could occur on your midterm/final exam. Bonus problems are not mandatory, but could bring you extra points.

Student Signature _____

Points_____/_____10_____

Designation	Symbol	Value	Units*
Atomic mass unit	u	1.660 566 (−27)	kg
Avogadro's constant (number)	N	6.022 045 (+26)	$kmol^{-1}$
Boltzmann constant	k	1.380 662 (−23)	$J \cdot K^{-1}$
Electric field constant	ϵ_0	8.854 223 (−12)	$C^2 \cdot N^{-1} \cdot m^{-2}$
Electronvolt	eV	1.602 190 (−19)	J
Electron charge	e^-	1.602 190 (−19)	C
Faraday constant	$\mathcal{F}$	9.648 456 (+07)	$C \cdot kmol^{-1}$
Gravitational acceleration	g	9.806 650 (+00)	$m \cdot s^{-2}$
Gravitational constant	G	6.672 000 (−11)	$N \cdot m^2 \cdot kg^{-2}$
Magnetic field constant	μ_0	1.256 640 (−06)	$N \cdot A^{-2}$
Mass of electron (rest)	m_e	9.109 534 (−31)	kg
Mass of neutron (rest)	m_n	1.674 954 (−27)	kg
Mass of proton (rest)	m_p	1.672 649 (−27)	kg
Planck constant	h	6.626 176 (−34)	$J \cdot s$
Speed of light in vacuum	c	2.997 925 (+08)	$m \cdot s^{-1}$
Speed of sound in air, 0°C	c_s	3.313 621 (+02)	$m \cdot s^{-1}$
Standard atmosphere	atm	1.013 250 (+05)	Pa
Standard kilomole volume	V_0	2.241 383 (+01)	$m^3 \cdot kmol^{-1}$
Thermochemical calorie	cal	4.184 000 (+00)	J
Universal gas constant	R	8.314 410 (+03)	$J \cdot K^{-1} \cdot kmol^{-1}$

*Problem 1. (3)

The nanograined alloy is produced with porosity p=0.6. The young modules of this nanograined material is found to be 20% smaller than the one of the corresponding bulk alloy. The nanograined alloy is additionally heat treated at 400 C, for 2 hours which decreased its porosity to 0.45. If the Young's module of bulk alloy is 350 GPa, what is the Young's module of heat treated nanograined alloy.

Problem 2. (3)

The nanograined material is found to deform by dislocation motion mechanism. It's yield stress is a function of the grain size and obeys Hall-Pitch relation with σ_0=250 MPa, and $\kappa \approx 2$. The main source of dislocations is Frank-Reed source operating in each nanograin once they are exposed to shear stress. I f the F-R source operates at 1GPa shear stress, and the shear module of this material G=0.8 GPa, find out what is the yield stress of this material. You can assume that Burger's vector of F-R source dislocation is of order of 1 A.

Problem 3. (3)

There is FCC material consists of nanograins which are about 5 nm in diameter. At room temperature the deformation occurs by Coble mechanism if the sample is exposed to stress σ_c, while at 1000 K the dominant deformation occurs by N-H mechanism if the sample is exposed to stress σ_{NH}. Assume that the diffusion coefficient in solid can be expressed as $D=D_0 \exp(-n_n * Eb/kT)$ where $Do=10^{-8}$ m^2/s, and n_n is the number of nearest neighbors, while Eb= 4 eV, is the energy of the bond. For grain boundaries the n_{nGB} is ¾ of that for the bulk material. If the strain rate achieved during deformation by either mechanism is the same, what is the ratio between σ_c and σ_{NH}.

Problem 4. (1) BONUS

One day there was a man in a hospital bed, and there was a man sitting next to him. So, the doctor asked the man sitting next to the man in the hospital bed, he asked, who are you? The man said listen closely for I will only tell you this once. Brothers and sisters I have none, but this man's father is my father's son. Who is this man?