Homework #4

Spring 2016

Due date: April 21th 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_____/_____

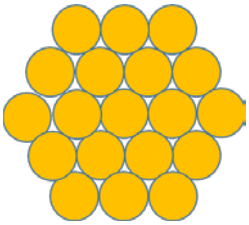
Designation	Symbol	Value	Units*
Atomic mass unit	u	1.660 566 (−27)	kg
Avogadro's constant (number)	N	6.022 045 (+26)	$kmol^{-1}$
Boltzmann constant	k	1.380 662 (−23)	$J \cdot K^{-1}$
Electric field constant	ϵ_0	8.854 223 (−12)	$C^2 \cdot N^{-1} \cdot m^{-2}$
Electronvolt	eV	1.602 190 (−19)	J
Electron 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. (1)

In maximum 100 words describe the difference between the ballistic and diffusive conductance. What is the numerical value of the lowest ballistic conductance?

Problem 2. (1)

On the figure below the cross-section of Au nanowire consisting of several atoms is depicted. If each atom in the cross-section represents one ballistic channel for conduction, what is the value of conductance of such Au nanowire?



Problem 3. (1)

Explain why the conductance of metallic noncontacts is often sad to exhibit a semiconducting behavior? (20 words max), give an example.

Problem 4. (1)

The adsorbed oxygen on CNT induces what kind of doping?, Name other types of doping elements used for CNT based FET.

Problem 5. (1)

What is the magnitude of the current density that SWCNT can support? How this compares to other materials which are good conductors like Ag or Cu for example.

Problem 6 (2)

Electrical conductivity of Ag-PMMA nanocomposite has been tested for different volume fractions of Ag nanoparticles. Data are shown below. Find out what is the dimensionality of conducting paths in the nanocomposite and what is the value of percolation threshold. (σ_{Ag} = 6.3x10^7 Sm^{-1})

σ/ Sm^{-1} x10^7	0.0008	1.4	2.2	3.6	4.0	4.4	4.7
Vol% of Ag	55	60	70	83	86	89	91

Problem 7 (2)

Assuming you have found percolation threshold for above problem, find out what is the aspect ratio of Ag nanoparticles. For this problem, you can assume that the ratio between cube of average length and average volume of Ag nanoparticles, $\langle L \rangle^3 / \langle L^3 \rangle$ is 0.2,. If $\langle L \rangle$ is 20 nm, what is the diameter of Ag nanoparticles in this composite?

Problem 8. (1)

The goal is to make PMMA conductive by addition of Au nanoparticles or nano-rods. The average size of Au nanoparticle available is 50 nm, while the Au nano-rods have diameter of 10 nm but length of 2 microns. Make your decision about what form of Au you would use based on optimum cost (lowest cost) of your composite.

Problem 9. (1)

Mo nanowires are grown by graphite step edge decoration technique3. Explain how many times diameter of Mo nanowire will increase if the growth time of the process is increased 100 times.