ECSE-2210 Microelectronics Technology
Class Activity 2
(Refer to next page for values of some physical constants)

1. A voltage of 10V is applied to point B with respect to point A in the figure below. Assume C is in the middle. If an electron at rest is placed at point C and released,

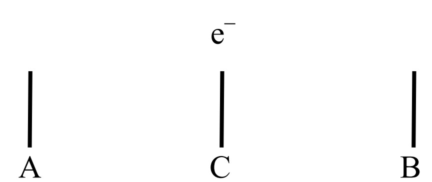
   a. In which direction will the electron move? Towards A or towards B?

   b. Calculate the electron energy in Joules when it reaches B.

   c. Calculate the electron energy in eV when it reaches B.

   d. What will be the electron velocity in m/s when it reaches B?

   e. Calculate the electric field $\mathcal{E}$ that exists between point A and point B if the distance between A and B is 5 cm. Indicate the direction of the $\mathcal{E}$–field by an arrow.



2. Calculate the energies (in eV) for the first three allowed orbits of the hydrogen atom.

3. Suppose an electron falls from the n = 3 orbit to the n = 2 orbit in hydrogen. Calculate the wavelength of radiation emitted during this process. Express this wavelength in Angstroms. Is the emitted light visible?

4. a. What is the number of Si atoms per cm^3?

   b. What is the **total** <u>number</u> of electrons present in 1 cm^3 of Si?

   c. What is the total number of electrons present in the valence band of Si at 0 K?

   d. How many electrons are free to conduct electricity at 0 K?

   e. Is Si an insulator or a conductor at 0 K?

5. Suppose you have some electrons to spare and you want to put them in the conduction band of Si. What is the total number of electrons/cm^3 that you can put in the conduction band ? (This is the number of states/cm^3 available in the band.)

6. Using the bond model for a semiconductor, indicate how one visualizes (a) a missing atom, (b) an electron (c) a hole (This is problem 2.2 in the textbook)

Some physical constants:

Planck's constant	$h = 6.63 \times 10^{-34}$ J s
Speed of light	$c = 3 \times 10^{8}$ m/s
Boltzmann constant	$k = 8.617 \times 10^{-5}$ eV/K
Electron rest mass	$m_0 = 9.11 \times 10^{-31}$ kg
Electron charge	$q = 1.60 \times 10^{-19}$ C
Permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}$ F/m

Some useful formulae:

Energy: $E = h\nu = \dfrac{hc}{\lambda}$; where ν is the frequency (s^{-1}) and λ is the wavelength (given in units of m).

Kinetic energy $E = (1/2)\, m\, v^2$ where v is the velocity (given in units of m/s).

$$E_{\mathrm{H}} = -\frac{mq^4}{8\varepsilon_0^2 n^2 h^2} = -\frac{9.11\times10^{-31}\mathrm{kg}\times(1.6\times10^{-19}\mathrm{C})^4}{8\times(8.85\times10^{-12}\mathrm{F/m})^2\times(6.62\times10^{-34}\mathrm{Js})^2} = -21.7\ \times\ 10^{-19}\ \mathrm{J}$$

for the $n = 1$ orbit of the hydrogen atom.

1 C × 1 V = 1 J (***Note***: The energy acquired by one **electron** passing a potential difference of 1 V is equal to 1.6×10^{-19} J. This energy amount is also called 1 eV).