Mansoura University	**First Semester (Final Exam.)**
Faculty of Engineering	**Exam Time: 3 Hours**
Department of Electronics and Communications Engineering	**Subject: Solid State Electronics**
1st Year Electronics	**Course code: COM 9112**
	Exam Date: 1-1-2013

Attempt all questions. Assume any missed data. Full mark is 100

Q.1.a) State Bohr's postulates for the hydrogen atom. Use these postulates to derive expressions for the orbit ***radius*** and orbit ***energy***.

- Sketch the energy level diagram and show Lyman, Balmer, and Paschen series on the diagram.
- What is the maximum photon frequency in Balmer series? **[10 Marks]**

Q.1.b) Write down the electronic configuration of iron. Can you guess why iron has magnetic properties? Give two examples for other elements with magnetic properties. **[5 Marks]**

Q.1.c) The spectral density of the sun peaks at a wavelength of 900 nm. If the sun behaves as a black body, what is the temperature of the sun? **[5 Marks]**

Q.2.a) X-rays of wavelength 8 pm are scattered from a target. Find:

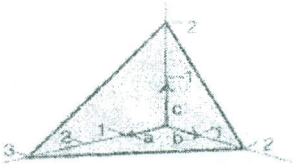
- The wavelength of the x-rays scattered through 45^{o}
- The maximum wavelength present in the scattered rays
- The maximum kinetic energy of the recoiling electrons **[5 Marks]**

Q.2.b) State the wave equation. Write down the 3-dimensional time-independent Schrödinger equation. Verify that the one-dimensional time-dependent Schrödinger equation is a solution of the wave equation. **[5 Marks]**

Q.2.c) Compare between each pair of the following: **[5 Marks]**

- Insulators and semiconductors (*using band theory of solids*)
- FCC lattice and BCC lattice

Q.2.d) *Define* Miller indices. The shown figure represents a part of a plane (the shaded triangle) which intersects the three axes x, y, z of a coordinate system. Find Miller indices for the shown plane. **[5 Marks]**



Q.3.a) Define *Fermi level*. Use energy band diagrams to compare its position in both intrinsic and extrinsic semiconductors. **[4 Marks]**

Q.3.b) *"The Hall effect is a phenomenon which is exploited to measure mobility and majority carrier concentration"*. Justify this statement, using sketches and necessary equations. **[6 Marks]**

Q.3.c) Assuming all dopant atoms are ionized, determine the conductivity for a sample of germanium, (width=2 *mm*, length=0.5 *cm*, thickness=250 μm), doped with $5*10^{18}$ *atoms/cm*^{3} of antimony. Find the percentage error when approximate relations are used.

($\mu_n = 3900 cm^2 V^{-1} s^{-1}$, $\mu_p = 1900 cm^2 V^{-1} s^{-1}$, $n_i = 2.5*10^{13} cm^{-3}$) **[6 Marks]**

Q.3.d) Define the term *"optical generation"*. Would photons of wavelength 1 μm be absorbed by silicon dioxide of bandgap *9 eV*? **[4 Marks]**

Q.4.a) Derive an expression for the contact potential of a pn junction in terms of electron concentration in n-side and p-side. **[5 Marks]**

Q.4.b) An abrupt silicon pn$^+$ junction 10^{-2} *cm*^{2} in area has $N_a = 2*10^{14} cm^{-3}$ doping on the p-side. Calculate the junction capacitance with a forward bias of *0.4V*. **[5 Marks]**

Q.4.c) Using *sketches only*, compare between the distributions of charge, potential, and electric field for a symmetric p-n junction and a one-sided abrupt p$^+$n junction. **[5 Marks]**

Q.4.d) Starting with Fermi-Dirac distribution function, $f(E) = \frac{1}{1+\exp[(E-E_f)/kT]}$, sketch the variation of $f(E)$ versus *E*, for T=0° *K*, 500° *K*, 1000° K, E_f=1 *eV* **[5 Marks]**

Q.5.a) Using E-k diagram, compare briefly between direct band-gap and indirect band-gap semiconductors. Give examples for each. **[5 Marks]**

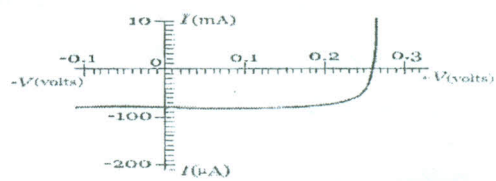
Q.5.b) Sketch a simple half-wave rectifier circuit. Apply a sinusoidal signal $V = 5\sin(100\pi t)$ to the input. Sketch the output waveform. **[5 Marks]**

Q.5.c) Design a photodetector circuit to detect infra-red (*1* μm) upwards. Sketch the V-I characteristics of the photodetector. **[5 Marks]**

Q.5.d) Using sketches, compare between LED and LASER diodes. **[5 Marks]**

Q.5.e) For a solar cell, what do the terms "fill factor & efficiency" refer to?

Calculate the fill factor for the solar cell characteristics shown in figure? **[5 Marks]**



You may need some or all of the following constants:

Electron mass = 9.1*10^{-31} Kg	Avogadro's number = 6.023*10^{23} atoms/mole
Electron charge = 1.6*10^{-19} C	Speed of light = 3*10^8 m/s
Planck's constant = 6.625*10^{-34} J.s.	Boltzman's Constant = 1.38*10^{-23} J/K°

My best wishes to all of you!

Assis. Prof. Hossam El-Din Moustafa
