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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX5543/ECX5243 Physical and Opto Electronics**
Academic Year	: 2017/18
Date	: 07th February 2019
Time	: 0930-1230hrs

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (08)** questions in **Three (03)** pages.
3. Answer **Only five questions** by answering selecting not more than two question form each section.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. Assume any missing parameters with suitable values.
7. This is a Closed Book Test (CBT).
8. Answers should be in clear hand writing.
9. Do not use Red colour pen.
10. All symbols have their usual meanings.

Note:

Charge of an electron = 1.602×10^{-19} C

Boltzmann constant = 8.617×10^{-5} eV K^{-1}

Planck's constant = 6.626×10^{-34} Js

Speed of light in a vacuum = 3×10^{8} m s^{-1}

Section A

Q1.

(a) As the temperature of either n-type or p-type semiconductor material increases how does the Fermi level move? [6]

(b) Determine the location of Fermi level with respect to E_c and E_v when 10^6 phosphorus atoms are added to a sample of intrinsic silicon at $T = 300$ K. $n_i = 1 \times 10^{10}$. [10]

(c) Repeat for $T = 600$ K and compare with the result in part (b). [4]

Q2.

(a) Briefly explain why the narrower the band gap the higher is the intrinsic carrier density in a semiconductor. [6]

(b) Assume that silicon, germanium and gallium arsenide each have dopant concentrations of $N_d = 1 \times 10^{13}$ cm^{-3} and $N_a = 2.5 \times 10^{13}$ cm^{-3} at $T = 300$ K. [10]

Material	n_i
Si	1.5×10^{10} cm^{-3}
Ge	2.4×10^{13} cm^{-3}
GaAs	1.8×10^{6} cm^{-3}

For each of the three materials

(i) Is this material n-type or p-type?

(ii) Calculate electron density n_0 hole density and p_0.

(c) Interpret your results in part (b). [4]

Q3.

(a) Why does a capacitance exist in a reverse biased pn junction? Why does it decrease with reverse biased voltage increasing? [6]

(b) Consider a uniformly doped silicon pn junction with doping concentrations $N_a = 5 \times 10^{17}$cm^{-3} and $N_d = 1 \times 10^{17}$cm^{-3}. Calculate the built in voltage V_0. [10]

(c) What will happen to V_0 when the temperature is increased by 5%. [4]

Section B

Q4.

(a) Define a hole. Bring out clearly its importance in the conduction of semiconductor material. [10]

(b) How does depletion region capacitance of a reverse biased diode vary with the magnitude of the reverse voltage? Explain. [10]

Q5.

(a) Discuss the condition when the base-collector junction become forward biased and hence the transistor enters the saturation region. [10]

(b) Clarify the situation when the pinch-off condition occurs for smaller values of $|V_{ds}|$. What will happen to the maximum drain current? [10]

Q6.

(a) Why are semiconductor photodiodes used almost exclusively as photodetectors for all optical communication systems? Discuss. [10]

(b) What is the significance of responsivity and quantum efficiency in characterizing a photodetector? Explain. [10]

Section C

Q7.

(a) List some of the main application areas of the semiconductor *pn* photodiode. [4]

(b) How is the p-i-n photodetector different from avalanche photodiode? [4]

(c) Photons having energy 1.5×10^{-19}J are incident on a photodiode having responsivity of 0.694 A/W. [12]

a. At what wavelength is the photodiode operating?
b. Calculate the quantum efficiency.
c. If the output power is 10 μW, find the generated photocurrent.
d. Determine the wavelength at which the quantum efficiency and the responsivity are equal.

Q8.

(a) Compare on

a. Single mode fiber and multi mode fiber
b. Step index fiber and graded index fiber

[6]

(b) Justify the statement "Multimode graded index fibers exhibit far less intermodal dispersion than multimode step index fibers". [5]

(c) A step index fiber has a numerical aperture $NA = 0.2588$, core refractive index $= 1.5$, cladding refractive index $= 1.47$ and a diameter 125 μm. A light sourse is coupled to this fiber which emits 75 % of its light into a 60 degree full-cone angle, 50 % into a 30 degree cone and 25 % into a 15 degree cone. Calculate the following when this source and fiber are connected [9]

a. Acceptance angle
b. Coupling efficiency
c. The critical angle at the core cladding interface