



UNIVERSITY OF GHANA

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BSc. (ENG) MATERIALS SCIENCE & ENGINEERING
END OF FIRST SEMESTER EXAMINATIONS: 2015/2016
MTEN 311: SOLID STATE TECHNOLOGY (3 Credits)
DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING

Answer All Questions

Time Allowed: 2.5 Hours

70 MARKS

1. The semiconductor PN diode is one of the basic devices whose principles of operation can be manipulated or engineered to produce modern day technological devices like the Solar Cell, Light Emitting Diodes (LEDs); Photodectors etc.

As a materials engineer working on projects to develop breakthrough technologies to augment current energy crisis facing Ghana;

(a) Describe and explain in your own words to your colleagues on the project who are non-device technologist, the fundamental principles of PN junctions and be used to generate electricity from solar radiation. **10 Marks**

(b) Describe and explain in your own words to your colleagues/team members on the project who are non-device technologist how the fundamental principles of PN junctions can be used to produce LEDs. **10 Marks**

2. Photonic technologies, including electronic displays, bio-sensors, solar cells, fiber optic communications and laser manufacturing, impact our lives almost every minute of every day. In fact, you may find it difficult to find a device these days that does not incorporate some form of optical technology:

(a) Photo detectors are used primarily as an optical receiver to convert light into electricity. The principle that applies to photo detectors is the photoelectric effect, which is the effect on a circuit due to light. Using a PN junction, describe the basic principles of photodiodes for photodetection. **5 Marks**

(b) The word *LASER* is an acronym for "light amplification by stimulated emission of radiation". Using the LASER acronym as basis, how do LASERS work? **15 Marks**

3. The metal-oxide-semiconductor (MOS) capacitor is the simplest fundamental unit of a MOS transistor used for amplifying or switching electronic signals. Sketch and label clearly the ideal band diagram of a MOS capacitor with a P-type silicon substrate and the cross-sectional area of NMOS transistor. **10 Marks**

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4. Quantum tunneling or tunneling refers to the quantum mechanical phenomenon where a particle passes through a barrier that classically it could not surmount. This plays an essential role in several physical phenomena, such as the nuclear fusion that occurs in main stars like the Sun. It has important applications to modern devices such as the tunnel diode, quantum computing, and the scanning tunneling microscope.

(i) Using your understanding of the wave-particle duality, the wave function and the Schrodinger equation explain this observation of quantum tunneling. **5 Marks**

(ii) Tunnel diode is a highly doped semiconductor device and is used mainly for low voltage high frequency switching applications. It works on the principle of Tunneling effect. Explain the fundamental principles behind the operations and applications of tunnel diodes. **5 Marks**

5.

(a) Describe the functions of (4) basic components in modern day devices

4 Marks

(b) As a Materials Engineer describe your role in a high tech semiconductor fabrication center.

6 Marks

