

UNIVERSITY OF GHANA
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BSc (ENG) MATERIALS SCIENCE AND ENGINEERING
END OF FIRST SEMESTER EXAMINATIONS: 2015/2016
DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING
MTEN 313: ELECTRICAL, MAGNETIC & OPTICAL PROPERTIES OF
MATERIALS. (3 CREDITS)

TIME ALLOWED: two and half (2 ½) HRS

Section A: Answer all Questions (10 marks)

1. A capacitor stores 0.24 coulombs at 10 volts. Its capacitance is;

- a) 0.024 F
- b) 0.12 F
- c) 0.60 F
- d) 0.80 F
- e) 0.31 F

2. If a dielectric material is inserted between the plates of an air capacitor, the capacitance will;

- a) decrease
- b) increase
- c) becomes zero
- d) remains unchanged
- e) becomes negative

3. In a capacitor the electric charge is stored in;

- a) metal plates
- b) dielectric
- c) both (a) and (b)
- d) edge of the plates
- e) none of the above

4) The energy stored by a capacitor is given by;

- a) $\frac{1}{2} CV^2$
- b) $Q^2 / 2C$
- c) $\frac{1}{2} QV$
- d) all of them
- e) $2Q/V$

5) Calculate the resistance of a 10 meter copper wire with a cross sectional area of 0.8 mm^2 if the resistivity of copper is $1.7 \times 10^{-8} \Omega \text{ m}$.

- a) 0.2113Ω
- b) 0.3125Ω
- c) 0.2125Ω
- d) 0.3000Ω
- e) 0.2000Ω

6) Magnetic property of all materials that opposes applied magnetic fields, but is very weak is known as;

- a) Ferromagnetism
- b) Paramagnetism

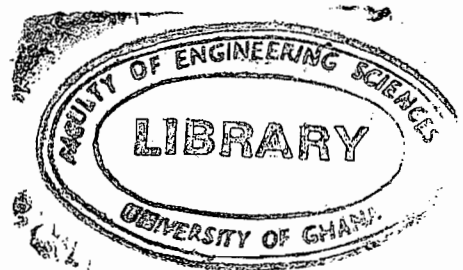
- c) Diamagnetism
- d) Ferrimagnetism
- e) Antiferromagnetism

7) The property of a material that describes the relation between a mechanical stress and an electrical voltage in solids is known as

- a) the pyroelectric effect
- b) superconductivity
- c) the piezoelectric effect
- d) the ferroelectric effect
- d) ferromagnetism

8) What is the energy of a photon of blue light (450 nm) in electron volts?

- a) 4.75 eV
- b) 1.77 eV
- c) 3.75 eV
- d) 2.75 eV
- e) 4.41 eV



9) Which of the following is not the property of capacitance;

- a) The area of the plates
- b) The distance between the plates
- c) The type of dielectric material
- d) The semiconductor nature of the plate
- e) Temperature

10) When ferromagnetic materials maintain magnetization below a certain temperature, that temperature is known as;

- a) Neel temperature
- b) Curie temperature
- c) Oswald temperature
- d) Magnetic temperature
- e) Peak temperature

Section B: Answer all Questions (60 marks)

1.

- a) Explain the term *capacitance* of a capacitor.
- b) Calculate the capacitance of a capacitor having dimensions, 30 cm x 40 cm and separated with an air-gap distance of 8 mm (permittivity of free space = $8.85 \times 10^{-12} \text{ C}^2/\text{N.m}^2$).
- c) Two conductors have net charges of $\pm 10 \mu\text{C}$ and a potential difference of 10 V exists across the conductors. What will be the potential difference that would be measured across the conductors if the charge on the conductors is increased to $\pm 100 \mu\text{C}$?

d) An air-spaced parallel-plate capacitor has an initial charge of $0.05 \mu\text{C}$ after being connected to a 10 V battery. What is the total energy stored between the plates of the capacitor?

e) A cell membrane can be modeled as a capacitor. What is the magnitude of the electric field across a cell membrane if the membrane is $1.1 \times 10^{-8} \text{ m}$ thick and a resting potential difference across the cell membrane is -70 mV ?

20 marks

2.

a) Write down three (3) factors that affects the apparent dielectric strength of a material.

b) What is piezoelectric effect and describe how the piezoelectric effect is observed in certain materials.

c) State the three (3) challenges that scientists and engineers are currently faced with in trying to tap into piezoelectricity as a viable electricity production method.

d) The amount of flux present in a square magnetic bar was measured to be 0.150 webers . If the material has a length of 5 cm , calculate the magnetic flux density.

e) With the aid of a diagram explain briefly the difference between ferromagnetism and ferrimagnetism.

20 marks

3.

a) Using the band model (theory) of solids, illustrate p- and n-type semiconductors and indicate the electrons and holes in the valence and conduction bands.

b) The bandgap energy of a semiconductor is 3.0 eV . Find the wavelength of a photon excited from such a semiconductor when illuminated with light. (Planck's constant is $6.626 \times 10^{-34} \text{ Js}$ and speed of light is $3 \times 10^8 \text{ m/s}$).

c) Name four (4) important features that must be considered when measuring the electrical properties (resistivity, carrier concentration and mobility) of a semiconductor thin film on a substrate using the Van der Pauw technique.

20 marks

