BOWEN UNIVERSITY, IWO. OSUN STATE. NIGERIA

COLLEGE OF AGRICULTURE, ENGINEERING, AND SCIENCE

PHYSICS PROGRAMME

SECOND SEMESTER EXAMINATION, 2022/2023 SESSION

PHY 426: PHYSICS OF THE NANOSCIENCE AND NANOTECHNOLOGY (1 CREDIT)

DATE: FRIDAY, JUNE 23, 2023. **TIME:** 8:30 A.M – 9:30 A.M

INSTRUCTION: ATTEMPT ANY TWO QUESTIONS **(Each question carries 50 marks)**

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Use the following constants where applicable.

Boltzman constant = 1.38×10^{-23} J/K

Charge on an electron e = 1.6×10^{-19} C,

1u (atomic mass unit) = 1.66×10^{-27} kg,

1 eV = 1.602×10^{-19},

Rest mass of proton = 1.007276u,

Rest mass of electron = 1.008665u

Rest energy equivalent (1u) = 931.494 MeV/u,

Mass of electron Me = 9.1×10^{-31} kg

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1. a. (i). What do you understand about nano-system energy conversion? **(3 marks)**
(ii) Mention four (4) types of nano-system energy conversion, you know. **(4 marks)**

b. (i) Give four (4) advantages of nano-system energy conversion **(4 marks)**
(ii) What are the challenges of nano-system energy conversion? **(8 marks)**

c. (i) Mention five (5) future directions for nano-system energy conversion research. **(5 marks)**
(ii) Write out a simple mathematical formula to calculate the efficiency of a thermoelectric generator, define the symbols used in the formula. **(8 marks)**

d. (i) A thermoelectric generator operates with a hot-side temperature of 400 K and a cold-side temperature of 300 K. If the generator absorbs 100 J of heat at the cold side and releases 200 J of heat at the hot side, calculate its efficiency. **(9 marks)**

(ii) A thermoelectric generator is designed to operate with an efficiency of 15%. If the cold-side temperature is 250 K and the generator absorbs 150 J of heat at the cold side, what should be the hot-side temperature to achieve the desired efficiency of hot-side heat of 112 J of energy? **(9 marks)**

2. a. (i) What you understand about nano-scale sensing? **(2 marks)**
(ii) State four (4) advantages of nano scale sensing you know. **(4 marks)**

b. (i) Give four (4) applications of nano scale sensing. **(4 marks)**
(ii) What are the challenges of nano scale sensing? **(6 marks)**

c. (i) Mention four (4) important parameters needed for nano scale sensing. **(6 marks)**
(ii) Give four (4) common sensing mechanisms used in nano scale sensing. **(4 marks)**

(8 marks)

d. (i) How are nanoscale sensors designed and fabricated?

(ii) A nanoscale sensor has a diameter of 50 nm and a length of 100 nm. Calculate its volume in cubic nanometers. **(8 marks)**

(iii) A nanoscale sensor is coated with a layer of gold nanoparticles that are 10 nm in diameter. If there are 1000 gold nanoparticles per square micrometer, calculate the number of gold nanoparticles that are present on the sensor's surface. **(8 marks)**

3. a. (i) As a Physicist, what do you understand by the word 'transport system'? **(3 marks)**

(ii) Give five (5) examples in the field of physics where 'transport' system is necessary. **(5 marks)**

b. (i) Briefly differentiate between ballistic and diffusive transport system in Physics. **(6 marks)**

(ii) Give two examples each for these two transport system above. **(4 marks)**

c. (i) State two factors affecting Ballistic transport and explain how they affect it. **(6 marks)**

(ii) Give three (3) laws from which diffusive transport equation is derived. **(6 marks)**

d. (i) 'Experimental techniques play a critical role in the study of transport phenomena, allowing scientists and engineers to measure the properties and behaviour of materials and devices.' Explain two of the experimental techniques usually used in these studies. **(6 marks)**

(i) A nanowire with a length of 100 nanometers is used for ballistic transport. An electron with a velocity of 1,000,000 m/s travels through the nanowire. Calculate the time it takes for the electron to travel through the nanowire. **(7 marks)**

(iii) A diffusive electron travels through a nanowire with a length of 50 nm and a diffusion coefficient of 10^{-3} cm^2/s at room temperature (300 K). Calculate the thermal velocity of the electron. **(7 marks)**

Moderated
04/06/2023