UNIVERSITY OF EMBU

2017/2018 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

SECOND YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION SCIENCE

SPH 203: STRUCTURE AND PROPERTIES OF MATTER

DATE: APRIL 3, 2018 **TIME: 11:00AM-1:00PM**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

Constants:

$c = 3.0\times10^{8}$ m/s	$e = 1.6 \times 10^{-19}$ C
$m_e = 9.1 \times 10^{-31}$ kg	$h = 6.6 \times 10^{-34}$ JS
$\varepsilon_o = 8.86 \times 10^{-12}$ C^2/Nm^2	$k = 1.38 \times 10^{-23} JK^{-1}$
$\mu_o = 4\pi \times 10^{-7}$ N/A.M	Y for steel $= 2.0 \times 10^{11} Nm^{-2}$
Surface tension of water $= 0.072\ Nm^{-1}$	$R = 0.0821 \times 10^{-23}$ J/K

QUESTION ONE (30 MARKS)

a) A beam of x - rays of wavelength $\lambda = 0.84 \times 10^{-10}$ m was incident on a crystal at a glancing angle of 8°35' when first order Braggs reflection occurs. Determine the glancing angle for the third order reflection. (3 marks)

b) Considering a hydrogen atom, calculate Rydbergs constant. (2 marks)

c) Show that in a adiabatic process of an ideal gas the relationship between pressure and volume is given by

$$PV^{\gamma} = constant$$

(2 marks)

d) By use of appropriate physical quantities compare isobaric and isochoric thermodynamic processes. (4 marks)

e) A liquid was heated to its boiling point while covered with a tight lid. Explain the pressure that shall act on the surface of the boiling liquid. (2 marks)

f) Briefly explain the conditions for existence of matter in plasma phase and consequently describe this phase of matter. (4 marks)

g) An airship has a volume of $3.0 \times 10^5\ m^3$. Determine how many kilograms of hydrogen would fit in it at 0.95 atm. And at 25 °C. (3 marks)

h) Explain the significance of Frank Hertz experiment with respect to atomic structure (2 marks)

i) By use of examples differentiate between extensive and intensive thermodynamic variables. (4 marks)

j) Determine the force required to stretch a steel wire to double its length when its area of cross-section is 1 cm^2. (2 marks)

k) A sphere of water of radius 1 mm was sprayed into a million drops all of the same size. Find the energy expended in doing this. (2 marks)

QUESTION TWO (20 MARKS)

a) A single electron orbits around a stationary nucleus of charge + Ze where Z is constant and e is the magnitude of the electronic charge. It requires 47.2 eV to excite the electron from the second Bohr's orbit to the third. Determine

i) The value of Z (5 marks)

ii) The wavelength of electromagnetic radiation required to remove the electron form the first Bohr's orbit to infinity. (5 marks)

iii) Energy required to excite the electron from the third to the fourth orbit. (5 marks)

iv) Total Energy of the atom. (5 marks)

QUESTION THREE (20 MARKS)

Consider a particle of gas of mass m confined within a rectangular box with edges parallel to X, Y and Z axis. Let the sides of the rectangular box be a (X axis), b (Y axis) and c (Z axis). Also consider that the particle can move freely within the region $0< x < a, < y < b$ and $< z < c$ i.e inside the box where potential V is zero. Show that the allowed values of total energy are given by:

$$E= E_x + E_y + E_z = \frac{h^2}{8m}\left[\frac{{n_x}^2}{a^2} + \frac{{n_y}^2}{b^2} + \frac{{n_z}^2}{c^2}\right]$$ (20 marks)

QUESTION FOUR (20 MARKS)

a) The element of an electric bulb attains steady temperature of 800 °C when connected to its normal power supply. If the power supply is increased by 20 % find the steady temperature the element will attain. (Assume the element is a black body and that all the heat is lost by radiation and the heat from the surroundings is negligible. (5 marks)

b) Consider a rectangular box of length l_1 with area it's at ends as A_1 andA_2. A single molecule with speed v_x travels left and right to the walls of the box and collides with the walls. Prove that the ideal gas equation is given by:

$$PV = nRT$$ (15 marks)

QUESTION FIVE (20 MARKS)

a) Find the eigen values of the matrix A below:

$$A=\begin{pmatrix}1 & -3 & 3\\ 3 & -5 & 3\\ 6 & -6 & 4\end{pmatrix}$$ (12 marks)

b) Explain the wave particle duality of x rays (8 marks)

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