NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF TECHNICAL TEACHER EDUCATION

GENERAL EXAMINATION

SPH 1106 – MODERN PHYSICS FOR CHEMISTS

BEd PART 1: September 2010 **DURATION: 3 HOURS**

Instructions To Candidates:

1. Answer **ALL** parts of question 1 in Section A.
2. Answer any **THREE** questions from Section B.
3. Section A carries 40 marks and section B carries 60 marks.
4. Show all your steps clearly in any calculation.

Planck's Constant,	$h=6.63 \times 10^{-34}$ J.s
Electron rest mass,	$m_c = 9.11 \times 10^{-31}$ kg
Speed of light,	$c = 3.00 \times 10^{8}$ m s
1 electron volt	$e = 1.60 \times 10^{-19}$ J
Mass of electron,	$m_e = 5.48 \times 10^{-4}$ u
Mass of proton,	$m_p = 1.007\ 825$ u
Mass of neutron,	$m_n = 1.008\ 665$ u
1 atomic mass unit,	$1u = 931.49$ MeV/c^2
Electronic Charge,	$e = 1.60 \times 10^{-19}$ C
Stefan – Boltzmann constant	$\sigma = 5.67 \times 10^{-8}$ W/m^2 .K^4
Wien's constant,	$k = 2.899 \times 10^{-3}$ m.K
Mass of Helium	$^4H_e = 4.002\ 603$ u
Mass of Oxygen	$^{16}_{8}O = 15.9994$ u
Mass of Hydrogen	$^1H = 1.007825$u
Radius of Earth	$R_E = 6.37 \times 10^6 m$

SECTION A

1. (a) (i) Define a blackbody [2]

(ii) Define the Bohr radius [2]

(b) Electrons are ejected from a metallic surface with speeds ranging up to 4.6×10^5 m/s when light of wavelength λ =625 nm is used.

(i) What is the work function of the surface? [2]

(ii) What is the cutoff frequency for this surface? [2]

(iii) Define the stopping potential? [2]

(ii) What is the temperature of the black body whose emitted radiation is most intense at a wavelength of 0.9μm. [3]

(c) (i) State Bohr's postulates for his model of the atom. [3]

(ii) What does the "Ground state" mean for the hydrogen atom and why is energy associated with this state negative? [4]

(iii) Explain what is meant by wave particle duality. [3]

(d) (i) State the conditions required to sustain nuclear fusion in stars? [3]

(ii) At what speed must an electron move so that its de Broglie wavelength equals its Compton wavelength? [4]

(e) Calculate the minimum wavelength of X-ray photons from an X-ray tube operating at 10 kV. . [4]

(f) Determine the mass deficit and the binding energy per nucleon of ${}^4_2He$. [6]

SECTION B

2. (a) With the aid of diagrams describe the generation x-rays in an x-ray tube making particular reference to the various processes an energies involved. [6]

(b) Define somatic and genetic damage. [4]

(c) (i) Write down the electronic configuration of the ground state for carbon (Z=6). [2]

(ii) Write out the values for the set of quantum numbers ^{n,l,m_l,m_s} for each of the electrons in carbon. [8]

3. (a) Briefly describe an application of the photoelectric effect. [2]

(b) When sodium metal is illuminated with light of wavelength 2.9 x 10^2 nm, the maximum kinetic energy of the ejected photoelectrons is 3.69eV.

(i) Define the term 'work function'. [2]

(ii) Find the 'work function' of sodium. [3]

(c) With the aid of diagrams describe the processes of pair production and pair annihilation. [8]

(d) Give the generic equations for beta decay and state the properties of a neutrino. [5]

4. (a) A sample of living tissue has activity of 12 Ci. Knowing that the half life of carbon-14 is 5730 years calculate the age of a fossil whose activity is 8 Ci. [5]

(b) Write down the reaction equations of the proton-proton cycle. [3]

(c) Describe the operation of an electron microscope with particular reference to wave properties of electrons. [8]

(d) What is the kinetic energy of electrons with a wavelength of 1.0 x 10^{-11} m? [4]

5. a) Give a detailed description with the aid of diagrams of the generation of bremsstrahlung radiation and characteristic radiation. [7]

(b) State Bohr's postulates of the hydrogen atom. [5]

(c) List the all the quantum numbers and the limits of what values they can take. [8]

6. a) Show that the radius for the n^{th} orbit of Bohr's model of the hydrogen atom is given by:

$$r_n = \frac{4\pi\varepsilon_0 \hbar^2}{me^2} n^2$$

[7]

(b) Calculate the volume of a proton (hydrogen nucleus). [4]

(c) Calculate the volume of the hydrogen atom when it is in its ground state. [4]

(d) Hence comment on Rutherford's planetary model of the atom. [3]

(e) State Bohr's correspondence principle. [2]

END OF EXAM