TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR DEGREE OF:

BACHELOR OF TECHNOLOGY IN RENEWABLE ENERGY (BTRE 13S)
BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS (BTAP 13S)

APS 4205: MODERN PHYSICS

END OF SEMESTER EXAMINATION
SERIES: DECEMBER 2014
TIME ALLOWED: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FIVE** questions
Answer question **ONE (COMPULSORY)** and any other **TWO** questions
Maximum marks for each part of a question are as shown
This paper consists of **THREE** printed pages

All symbols have their usual meaning
You may use where necessary:

Speed of light in a vacuum	= 3 x 108ms^{-1}
Atomic mass unit μ	= 1.660565 x 10^{-27}kg = 931Ev
Electron volt 1Ev	= 1602189 x 10^{-19}J
Electron rest mass	= 9.109534 x 10^{-31}kg
Plank's constant	= 6.626 x 10^{-34}Js
Avogadro's number N_A	= 6.02 x 102^{3}
Electronic charge	= 1.6 x 10^{-19}C

Mass of one atom of random = 222u
Rydberg's constants = $1.897 \times 10^{-7} m^{-1}$

Question One (Compulsory)

a) Other than relative motion, which is commonly experienced is there an absolute motion? Explain your answer. **(2 marks)**

b) Show that there is a time dilation for a clock that moves at a relativistic velocity v relative to an observer who is on the ground taking readings. **(5 marks)**

c) State the major deficiencies of Rutherford's Nuclear model. **(2 marks)**

d) Explain the following terms:
- **(i)** Nuclear fission **(1 mark)**
- **(ii)** Nuclear fusion **(1 mark)**
- **(iii)** Mass defect **(1 mark)**
- **(iv)** Binding energy **(1 mark)**

e) X rays of wavelength 10×10^{-12}m are scattered from a stationary target. Find:
- **(i)** The maximum wavelength f the x-rays scattered through 45^o **(3 marks)**
- **(ii)** The maximum kinetic energy of the recoil electrons **(3 marks)**

f) A polonium isotope $^{210}_{84}P$ is unstable and emits 5.3MeV alpha particle. The atomic mass of $^{210}_{84}P_o = 209.9829$ a.m.u and that of Helium $^{4}_{2}He = 4.0026$ a.m.u:
- **(i)** Identify the daughter nucleus and **(2 marks)**
- **(ii)** Find its atomic mass **(3 marks)**

g) A metre stick appears only 50cm long to an observer. What is its relative speed and how long does it take to pass the observer? **(3 marks)**

Question Two

a) Tom was able to see leah doing calculation in her space plane that was moving at 0.5c. Tom who is in an inertial frame that is at rest uses his clock and notices that she takes exactly one minute to finish her calculation. How much time did she take by his (Tom's) clock? **(5 marks)**

b) (i) Show that two clocks that are a metre apart, which were initially synchronized while the train was at rest, appears unsynchronized as viewed from the ground when they move at a relativistic motion with the same velocity. **(6 marks)**
(ii) Which clock in (i) above is a head and by how many seconds. **(2 marks)**
(iii) What happens when the clocks are moved closer? **(1 mark)**

c) Derive the Lorentz transformations. **(6 marks)**

Question Three

a) A monochromatic beam of x-rays with wavelength $\lambda = 1.3\times10^{-10}$ m is scattered by a metal foil. By what percentage is the wavelength shifted for the scattered component observed at an angle of 90°? **(5marks)**

b) Show that the half life of a radioactive element is given by $T_{1/2} = \frac{0.693}{\lambda}$, where symbols have their usual meaning. **(5 marks)**

c) Find the activity of one milligram of Radom whose half life is 3.8 days **(5 marks)**

d) Ultraviolet light of wavelength 350mm had intensity of $1W/m^2$ directed at a potassium surface. Find the maximum kinetic energy of the photoelectrons emitted (work function of potassium = 2.2eV) **(5 marks)**

Question Four

a) (i) What are elementary particles? **(2 marks)**
(ii) State three other elementary particles apart from leptons **(3 marks)**
(iii) What is an antiparticle of an elementary particle? **(1 mark)**

b) Show that the binding energy per nucleon is maximum when packing fraction is minimum. **(6 marks)**

c) What is the wavelength of the emitted light when excited electrons in the hydrogen atoms make transition from the n = 3 in the Balmer series. **(5 marks)**

d) Derive an expression for Broglie wavelength of a moving body. **(3 marks)**

Question Five

a) From the Bose-Einstein distribution function, obtain the Stefan's-Boltzmann law for a perfect black body. **(8 marks)**

b) Find the atomic spacing, d, for a crystal of rock salt (Nacl) whose formula mass is 58.5u and whose density 'ρ' is $2.16 \times 10^3 kgm^{-3}$. **(3 marks)**

c) State FIVE properties of x-rays. **(5 marks)**

d) (i) What are quarks? **(1 mark)**
(ii) Name the original three quarks **(3 marks)**