KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

SECONG YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: SPC 222

COURSE TITLE: MODERN PHYSICS

DATE: 26/07/2022 **TIME:** 11:00AM-1:00PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

QUESTION 1

a) A meter stick appears only 60cm to an observer. What is its relative speed? How long does it take to pass the observer? (4mks)

b) Ultraviolet light of wavelength 350nm and intensity 1w/m2 is directed at a potassium surface. Find the maximum K.E of the photoelectrons given that the work function of potassium is 2.2eV. (4mks)

c) Find the atomic spacing for a crystal of rock salt, Nacl, whose formula mass is 58.5u and whose density is $2.16 \times 10^3 kg/m^3$. (4 mkhs)

d) Sate the Pauli's exclussion principle. (1mk)

e) A measurement establishes the position of a proton with an accuracy of $\pm 10^{-11}$m. Find the uncertainty in the proton's position 1s later. Assume V<<<<c. (4mks)

f) Find the de Broglie wavelength of :

(i) A 46-g golf ball with a velocity of 30m/s. (3 mks)

(ii) An electron with a velocity of 107m/s. (3 mks)

g) A 5MeV alpha particle approaches a gold nucleus with an impact parameter of 2.6×10^{-13} m. Through what angle will it be scattered? (2mks)

Solution

h) What is the impact parameter of a 5MeV alpha particle scattered by 10o when it approaches a gold nucleus? Chemical formula for gold is $^{197}_{79}Au$ (2mks)

Solution

i) Define Radioactivity. (1mk)

j) The Polonium isotope $^{210}_{84}Po$ is unstable and emits a 5.3MeV alpha particle. The atomic mass of $^{210}_{84}Po4$ is 209.9829u and that of $^{4}_{2}He$ is 4.0026u. Identify the daughter nucleus and find its atomic mass. (4mks)

QUESTION TWO

a) A reference frame S' moving at a velocity v relative to another frame S. The displacement of each frame after time t is $x' = k(x - vt)$ and $x = k(x' + vt')$ respectively. Show that the Lorentz transformation from S to S' is

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}},$$

$$y' = y,$$

$$z' = z,$$ (10mks)

$$\text{and } t' = \frac{x'}{c} = \frac{1}{c}\left(\frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}\right) = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

b) A certain particle has a lifetime of 10^{-7}s when measured at rest. How far does it go, before decaying, if its speed is 0.99c when it was created? (4mks)

c) If u and u′, are the velocities with reference to the observer at O and O′ respectively, such that

$$\left.\begin{aligned} u &= \frac{x_2 - x_1}{t_2 - t_1}, \\ u' &= \frac{x_2' - x_1'}{t_2' - t_1'}, \end{aligned}\right\}$$

Show that if $u = c$ then $u' = c$. (6mks)

QUESTION THREE

a) Show that for a body moving with acceleration $a = \frac{d}{dt}\left(\frac{V}{\sqrt{1-\frac{v^2}{c^2}}}\right)$ its kinetic energy is given by K. E. $= \frac{1}{2} m_0 v^2$. (10 mks)

b) Show that for a massless particle, its momentum and energy are related by $E = Pc$ where is the speed of light. (10mks)

QUESTION FOUR

Derive the Raleigh-Jeans formula. (20mks)

QUESTION FIVE

a) A photon of mass m_0 and wavelength λ is scattered through an angle and changes into a new photon of wavelength λ'. Show that

$$\lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\phi) \qquad (12 \text{ mks})$$

b) X-rays of wavelength 10×10^{-12} m are scattered from a target.

(i) Find the wavelength of x-rays scattered through 45^o (3mks)

(ii) Find the maximum wavelength present in the scattered x-rays. (2mks)

(iii) Find the maximum K.E of the recoil electrons. (λ_c of an electron is 2.424pm) (3mks)