KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHYS 220

COURSE TITLE: INTRODUCTION TO QUANTUM PHYSICS

STREAM: SESSION IV

DAY: FRIDAY

TIME: 9.00 – 11.00 A.M.

DATE: 13/08/2010

INSTRUCTIONS:

1. *This paper contains four questions. Answer **Question 1** and any other **two** questions.*
2. *Question 1 contains **40** marks and the rest contain **15** marks each.*
3. *Where needed use the constants; $g = 9.8ms^{-2}$, $m_e = 9.11x10^{-31}kg$, $h = 6.63x10^{-34}Js$, $C = 3\ x10^{8}ms^{-1}$, viscosity η of castor oil = 986, charge $e = 1.6x10^{-19}$, $\varepsilon_O = 8.85x10^{-12}Fm^{-1}$. $\pi = 3.14$ and $R_H = 1.097X10^{7}m^{-1}$*

PLEASE TURN OVER

Question 1 (40 Marks)

a.) Define the term spectroscopy. (1 mark)

b.) Calculate the wavelength in nm of an electromagnetic radiation whose energy is 6.02×10^{-19}J. (3 marks)

c.) i.) Define the term threshold frequency (1 mark)
ii.) Explain why stopping potential V_S of a photoemitter is independent of intensity but depends on threshold frequency (3 marks)

d.) Give two postulates of Bohr atom (2 marks)

e.) What do you understand by the term ground state of a system? (1 mark)

f.) How does Compton effect differ from the photoelectric effect? (2 marks)

g.) Compute the de Broglie wavelength of an electron accelerated from rest through a potential of 900 V. (3 marks)

h.) i.) State the uncertainty principle (1 mark)
ii.) An electron is localized to within a distance of 1.0×10^{-10}m (approximately the diameter of a hydrogen atom).
1. Treat this as a one-dimensional problem and determine the uncertainty in the electron's momentum (3 marks)
2. What is the kinetic energy associated with this momentum (2 marks)

i.) Stars appear to have distinct colors. Some stars look red, some yellow and others blue. What is a the explanation for this? (2 marks)

j.) Explain the difference between emission spectra and absorption spectra. (2 marks)

k.) Give two failures of classical physics in explanation of some of atomic properties of matter. (2 marks)

l.) Calculate the wavelength in nm of a photon whose energy is 1.80eV (3 marks)

m.) Kinetic energy of electrons emitted from the surface of sodium metal is 0.43 eV. If the wavelength of this emission is 390 nm; find,
1. The work function of sodium
2. Maximum speed of electrons (6 marks)

n.) Find an expression for the energy of a photon in eV when the wavelength of the photon is given in nanometers (3 marks)

QUESTION TWO (15 MARKS)

a.) Draw electron orbits of Bohr's model of the hydrogen atom, showing the transition terms corresponding to the three first series of the spectroscopy (3 marks)

b.) What is the shortest wavelength of Lyman series of hydrogen? (3 marks)

c.) i.) Describe how x-rays are produced (2 marks)
ii.) What limits the minimum size of x-ray wavelengths? (1 mark)

d.) On the basis of Moseley's law, calculate the energy of the K_α from
i.) Gadolinium (Z = 64) and
ii.) Thorium (Z = 90) $R_\infty = 1.097 \times 10^7 m^{-1}$ (4 marks)

e.) Give two observations of photoelectric effect that could not be explained by classical physics (2 marks)

QUESTION THREE (15 MARKS)

a.) Using Compton Effect, show that energy is given as

$$\frac{hc}{\lambda} = \frac{hc}{\lambda'} + mc^2\left(\frac{1}{\sqrt{1 - {v^2}/{c^2}}} - 1\right)$$

Where the symbols have their usual meaning. (4 marks)

b.) Compute the de Broglie wavelength of a baseball of mass 0.145kg moving at a speed of $38ms^{-1}$ (3 marks)

c.) Explain the wave duality of matter (1 mark)

d.) The clean surface of sodium metal (in a vacuum) is illuminated with monochromatic light of various wavelengths and the retarding potentials required to stop the most energetic photoelectrons are observed as follows:

$\lambda(\mathring{A})$	2536	2830	3039	3302	3663	4358
Retarding potential V	2.60	2.11	1.81	1.47	1.10	0.57

Use a graph to obtain the numerical value for Planck's constant h. (7 marks)

QUESTION (15 MARKS)

a.) Determine the second Bohr radius of the hydrogen atom (2 marks)

b.) Using Bragg's reflection constructive interference, show that the wavelength of an incident x-ray can be given as;

$$\lambda = \frac{2d\sin\theta}{n}$$

where symbols have their usual meaning. (4 marks)

c.) An electron accelerated at $1.6x10^{7}ms^{-1}$ and a dust speck of mass $0.91x10^{-10}kg$ travels at $0.03ms^{-1}$. Calculate and compare their de Broglie wavelengths (3 marks)

d.) Photons of energy 14.4keV can be produced with a relative uncertainty in energy of one part in 10^{11}. What is the uncertainty in the lifetime of the state that emits such photons? (3 marks)

e.) What is the maximum recoil velocity of a free-electron that is scattered by an x-ray of wavelength $\lambda = 7.1x10^{-11}m$? (2 marks)