KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHYS 220**

COURSE TITLE: **INTRODUCTION TO QUANTUM PHYSICS**

STREAM: **SESSION V**

DAY: **FRIDAY**

TIME: **9.00 – 11.00 A.M.**

DATE: **15/04/2011**

INSTRUCTIONS:

- *Answer Question **ONE** and any other **TWO** Questions. Question One carries **30marks** while each of the other Two Questions carry 2**0marks**.*
- ***The following constants may be useful***
  - Mass of electron $m_e = 9.11\times10^{-31}\,Kg$
  - Planck's constant $h = 6.63\times10^{-34}\,JS$
  - Charge of electron $e = 1.6\times10^{-19}\,C$
  - Wien's displacement constant $= 2.898\times10^{-3}\,mK$
  - Stefan-Boltzman constant $= 5.67\times10^{-8}\,Wm^{-2}K^{-4}$

PLEASE TURN OVER

QUESTION 1 (30 marks)

a) State two failures of classical theories. (2mks)

b) i) What is black body radiation. (1mk)
ii) State two things that happen when the temperature of a body is increased. (2mks)
iii) State one application of black body radiation. (1mk)

c) i) State Wien's displacement law and give its mathematical equation. (2mks)
ii) Calculate the wavelength produced by a body at $25^0 C$. (2mks)

d) A circular plate of diameter 10cm heated to a temperature of $300^0 C$; calculate the total power of the radiation produced. (4mks)

e) i) State uncertainty principle. (1mk)
ii) The sped of a bullet and of an electron are measured as $u = 300 m/s$ with an accuracy of 0.01%. If the mass of the bullet is 50g; determine
i). Δu for each (2mks)
ii). ΔX for each (5mks)
iii). Explain the differences in your answers in (ii) above. (1mk)

f) i) What is wave – particle duality? (1mk)
ii) The speed of a particle is $180 Km/hr$. Calculate its radius if it has a mass of 0.0025Kg and orbiting ground state. (3mks)

g) State three properties used to detect X-rays. (3mks)

QUESTION 2 (20 marks)

a) i) What is Compton effect? When is it observed? (2mks)
ii) Derive the Compton effect formula (8mks)
iii) An electromagnetic radiation of frequency $1.5\times10^{15} Hz$ strikes a target and scattered at an angle of 35^0. Find the new wavelength. (4mks)

b) A radioactive element decays to form a stable nuclide according to the equation

$$^{234}_{92}U \rightarrow ^{206}_{82}Pb + particles$$

Identify the number and type of radiations produced (3mks)

c) The half life of a certain sample is 4 minutes. The sample was measured and found to contain 0.48g, find how much of the sample was present 20 minutes before the measurement was done. (3mks)

QUESTION 3 (20 marks)

a) Differentiate between the following. (4mks)

i). Absorption and emission spectra

ii). Nuclear fission and fusion

b) i) Name the particles of an atom and state their charges (3mks)

ii) A nuclide notation is written as

$$^{A}_{Z}X$$

State what the symbols; A, Z and X stands for. (3mks)

c) Given that $\Delta x = 5.0\times10^{-15}\,m$, determine

i). Δp (2mks)

ii). Percentage error in p (3mks)

d) The activity of sample X is $2.5\times10^{6}\,counts/\sec ond$. If 1g of the sample is studied, calculate

i). the decay constant (3mks)

ii). the half life (2mks)

QUESTION 4 (20 marks)

a) i) State and prove De-Broglie hypothesis. (4mks)

ii) Derive De-Broglie wavelength formula. (4mks)

b) Bean of electrons were accelerated by a potential difference of 250V and directed at a crystal with plane separation $x = 6.4\times10^{-9}\,m$. Calculate;

i). De-Broglie wavelength. (3mks)

ii). First second order angle of diffraction. (3mks)

iii). Radius of the electrons if orbiting the second shell. (3mks)

c) State three limitation of Bohr model of atom. (3mks)

QUESTION 5 (20 marks)

a) i) Explain how X-rays are produced and state the conditions which influence the quality and intensity of X-rays produced. (3mks)

ii) Calculate the wavelength of the X-ray produced when a potential difference between cathode and anode is set to $2.5\times10^{5}\,V$. (3mks)

b) i) State radioactive decay law. (1mk)

ii) Show that the half life of a radioactive material is given by

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

Where λ is the decay constant of the material. (4mks)

c) Define the following as used with photo electric effect (3mks)

i). Work function
ii). Threshold frequency
iii). Photons

b) i) State Einstein's equation of photo electric effect. (1mk)

ii) The work function of a metal surface is 5.4eV. Calculate,

I. The kinetic energy of photoelectrons produced if the metal is illuminated by radiation of frequency $1.8\times10^{15}\,Hz$. (3mks)

II. The maximum velocity of photoelectrons produced (2mks)