

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 20marks.*
- *The following constants may be useful*
 - Mass of electron $m_e = 9.11 \times 10^{-31} \text{ Kg}$
 - Planck's constant $h = 6.63 \times 10^{-34} \text{ JS}$
 - Charge of electron $e = 1.6 \times 10^{-19} \text{ C}$
 - Wien's displacement constant = $2.898 \times 10^{-3} \text{ mK}$
 - Stefan-Boltzman constant = $5.67 \times 10^{-8} \text{ Wm}^{-2} \text{ K}^{-4}$

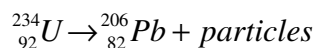
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QUESTION 1 (30 marks)

- 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 $25^{\circ}C$. (2mks)
- d) A circular plate of diameter 10cm heated to a temperature of $300^{\circ}C$; calculate the total power of the radiation produced. (4mks)
- e) i) State uncertainty principle. (1mk)
ii) The speed of a bullet and of an electron are measured as $u = 300m/s$ 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 $180Km/hr$. 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 $1.5 \times 10^{15} Hz$ strikes a target and scattered at an angle of 35° . Find the new wavelength. (4mks)
- b) A radioactive element decays to form a stable nuclide according to the equation



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



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

c) Given that $\Delta x = 5.0 \times 10^{-15} \text{ m}$, determine

- i). Δp (2mks)
- ii). Percentage error in p (3mks)

d) The activity of sample X is $2.5 \times 10^6 \text{ counts/second}$. 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) Beam of electrons were accelerated by a potential difference of 250V and directed at a crystal with plane separation $x = 6.4 \times 10^{-9} \text{ m}$. 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 $2.5 \times 10^5 \text{ V}$. (3mks)

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

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

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

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 $1.8 \times 10^{15} \text{ Hz}$. (3mks)
- II. The maximum velocity of photoelectrons produced (2mks)