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MAIN EXAMINATION

JANUARY – APRIL 2018 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 418: ATOMIC PHYSICS

Date: APRIL 2018	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

You may use the following constants

- Electronic charge, e =106 x 10^{-19} C
- Mass of Electron m_e = 9.11 x 10 $^{-31}$ kg
- Permittivity of Vacuum $\varepsilon_o = 8.85 \text{ x } 10^{-12}$ Fm
- Permeability of vacuum $\mu_o = 4\pi \text{ x } 10^{-7}\text{Hm}^{-1}$
- Planck's constant $h = 6.63 \text{ x } 10^{-34}$ Js
- Rydberg's constant $R = 0.011\ nm^{-1}$
- Speed of light in a vacuum c =3.0 x 10^8 m/s

Q1. a) State the constituents of an atom **(3 marks)**

b) List any three Bohr's postulates **(3 marks)**

c) Differentiate between Stark's effect and Zeeman's effect **(2 marks)**

d) i) Briefly describe Rutherford's atomic model **(3 marks)**

ii) Calculate the energy emitted by a photon of wavelength 5.2 x 10^{-11} m. **(3 marks)**

e) Calculate the wavelength of light emitted when the electron in a hydrogen atom falls from the first excited state to the ground state level. **(4 marks)**

f) i) What are X-rays? **(1 mark)**

ii) Differentiate between hard and soft X-rays **(2 marks)**

iii) The frequency of X-rays is given as 4 x 10^{17}. Determine the energy possessed by the X-rays **(3 marks)**

g) i) What is Compton scattering **(1 mark)**

ii) Describe the terms in the Compton scattering equation below **(4 marks)**

$$\lambda_2 - \lambda_1 = \frac{h}{mc}(1 - cos\theta)$$

Q2. a) Using a well labeled diagram of an X-Ray tube, describe how X-rays are produced **(6 marks)**

b) Only 0.2% of the energy of an electron is transferred to X-Rays. Where do the rest of the energy go? Explain your answer **(3 marks)**

c) What is the effect of increasing the accelerating voltage on the X-Ray produced **(2 marks)**

d) A potential difference of 40kV is applied across an x-ray tube . calculate:

i) Energy of electrons as they arrive at the target **(3 marks)**

ii) Velocity of electron at the target **(4 marks)**

e) State any two uses of X-rays **(2 marks)**

Q3. a) Describe Rutherford 's alpha scattering experiment hence the Rutherford's atomic model **(7 marks)**

b) List the four Bohr's postulates **(4 marks)**

c) Show that the Bohr radius is given by **(7 marks)**

$$r_1 = \frac{\hbar^2}{ke^2m}$$

d) Differentiate between absorption and emission spectra **(2 marks)**

Q4. a) What is Compton scattering **(2 marks)**

b) With the aid of a well labeled diagram derive the Compton scattering formula **(10 marks)**

$$\lambda_2 - \lambda_1 = \frac{h}{mc}(1 - cos\theta)$$

c) An x-ray photon with a wavelength of 9.73 x 10^{-2} nm scatters off a free electron at an angle of $30^{0.}$ Determine

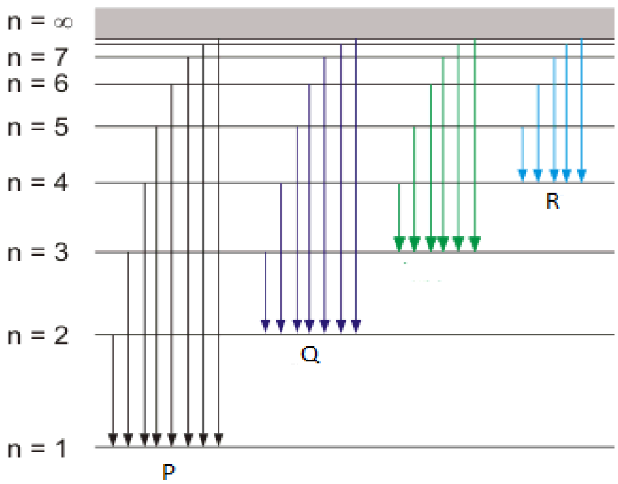
i) the change in wavelength for the photon **(3 marks)**

ii) the wavelength of the scattered photon **(2 marks)**

iii) the kinetic energy of the electron as it recoils **(3 marks)**

Q5. a) What is a spectrum **(1 mark)**

b) The figure below shows a spectral line series for hydrogen atom. Identify the series marked P,Q,R **(3 marks)**



c) Calculate the highest velocity, the smallest orbit radius and the time it takes for an electron to complete one revolution in a hydrogen atom. **(8 marks)**

d) State any four drawbacks of Bohr's model of the atom **(4 marks)**

e) Estimate the speed of electron before collision when applied accelerating voltage is 30,000 V and compare it with the speed of light in vacuum. **(4 marks)**

END