

THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF PHYSICS

PHYS2110/PHYS2040 QUANTUM PHYSICS
EXAMINATION – FRIDAY 11th APRIL 2014
PAPER 1 – MID SESSION

Time allowed = 50 min.

Total number of questions = 3

Total number of marks = 40

Answer ALL questions

The questions are NOT of equal value

Portable battery powered electronic calculators (without alphabetic
keyboards) may be used

The paper may be retained by the candidate

Please write your answers in ink but do not use red ink

The following information is supplied as an aid to memory.

Planck's constant $h = 6.626 \times 10^{-34}$ Js

Fundamental charge unit $e = 1.60 \times 10^{-19}$ C

Speed of light (vacuum) $c = 3.0 \times 10^8$ m/s

Electron mass = 9.1×10^{-31} kg

Neutron mass = 1.675×10^{-27} kg

Proton mass = 1.672×10^{-27} kg

Boltzmann's constant $k = 1.38 \times 10^{-23}$ JK⁻¹

Angstrom (Å) = 1.0×10^{-10} m

Permittivity constant $\epsilon_0 = 8.85 \times 10^{-12}$ Fm⁻¹

Gravitational constant $G = 6.67 \times 10^{-11}$ Nm²/kg²

$\sin 2\theta = 2 \sin \theta \cos \theta$ Bragg's law: $2d \sin \theta = m\lambda$

Compton Shift: $\Delta\lambda = \frac{h}{mc}(1 - \cos \theta)$

Question 1 [18 marks]

- (a) If the de Broglie wavelength of an electron is equal to that of a proton, which has the larger speed? Why?
- (b) Light of a certain wavelength is incident on potassium metal, which has a work function of 2.3 eV. The stopping potential is 0.7 V. Calculate the wavelength of this light.
- (c) A particle of mass m has a positional uncertainty equal to its de Broglie wavelength. Calculate the minimum **fractional** uncertainty in its velocity $\Delta v/v$.

Question 2 [12 Marks]

An x-ray of wavelength $\lambda = 1.0 \times 10^{-11} \text{ m}$ is Compton scattered at an angle 85° .

- (a) What is the wavelength of the scattered X-ray and how much energy has the photon lost?
- (b) What is the mass of the electron after the collision?

Question 3 [10 marks]

The typical energy needed to ionise an atom is around 5 eV. Use the Uncertainty Principle to estimate the size of an atom.