THE UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF PHYSICS

PHYS2110/PHYS2040 QUANTUM PHYSICS

EXAMINATION – APRIL 18 2013

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 $\varepsilon_o = 8.85 \times 10^{-12}$ Fm^{-1}

Gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2/kg^2

$\sin 2\theta = 2\sin\theta\cos\theta$ Bragg's law: ~~$\sin 2\theta = 2\sin\theta\cos\theta$~~ Compton Shift: $\Delta\lambda = \frac{h}{mc}(1-\cos\theta)$

$n\lambda = 2d\sin\theta$

Question 1 [15 marks]

(a) Write down, concisely, the postulates (assumptions) of the Bohr model of the atom.

(b) Based on Bohr's postulates, derive expressions for the energy levels and the radii of the electron of a hydrogen atom in the ground state and the excited states as a function of n. Give the numerical results in eV and in nm.

(c) An excited hydrogen atom emits light of wavelength 122 nm. Between which electronic levels does the transition take place?

(d) Explain, concisely, the limitations of the Bohr model.

Question 2 [15 marks]

(a) Describe **briefly** the Davisson-Germer experiment and its significance for Modern Physics.

(b) To what kinetic energy (in eV) must an electron be accelerated such that its de Broglie wavelength is equal to that of the shortest wavelength X-rays produced in an X-ray tube operating at 50,000 V ?

(c) If the de Broglie wavelength of an electron is equal to that of a proton, which has the larger speed ? Why ?

(d) 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.

(e) 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 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.