

Option B — Quantum Physics and Nuclear Physics

- B1.** (a) the electron in the hydrogen atom exists in states of specific energy;
 a photon is emitted every time a transition to a lower energy state is made,
 of energy equal to the difference in energy between the levels involved in the
 transition;
 since the photon energy is given by $E = hf$ the frequency of the emitted photon is
 specific / *OWTTE*; [3]
- (b) (i) the energy can only have the values given on the diagram / energy
 corresponds to $n = 1, 2$ etc.; [1]
- (ii) the energy difference is 10.2 eV;

$$\frac{hc}{\lambda} = 10.2 \Rightarrow \lambda = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{10.2 \times 1.60 \times 10^{-19}};$$

$$= 1.22 \times 10^{-7} \text{ m}$$
 [2]
- (iii) as n increases energy levels become closer together;
 energy transitions (between levels) become more equal hence wavelengths
 become more equal / *OWWTE*; [2]
- (c) particles have an associated wavelength;
 the electron in the atom has an undefined position;
 the square of the wavefunction gives the probability of locating the electron;
 the electron wavefunction has to fit boundary conditions that leads to energy levels; [4]
- B2.** (a) ${}_{81}^{207}\text{Tl} \rightarrow {}_{82}^{207}\text{Pb} + {}_{-1}^0e + \bar{\nu}$
 inclusion of electron ${}_{-1}^0e$;
 inclusion of antineutrino $\bar{\nu}$; [2]
Do not accept beta plus decay.
- (b) (i) the nucleus is in an excited state;
 drops to the ground state by emission of gamma ray photons; [2]
- (ii) beta decay involves the emission of antineutrinos;
 energy is shared between the produced particles; [2]
- (c) (i) the weak interaction; [1]
*Accept the electromagnetic interaction for those who concentrated on the
 photon emitted.*
- (ii) W boson; [1]
Accept the photon for those who have the electromagnetic interaction in (i).

[1]

H4. (a) first diffraction minimum at $\theta = 4.25 \times 10^{-3}$ rad

$$\lambda \approx b\theta = 1.2 \times 10^{-4} \times 4.25 \times 10^{-3} = 5.1 \times 10^{-7} \text{ m};$$

[1]

Accept answers in the range 5.0×10^{-7} m to 5.2×10^{-7} m.

(b) central maximum (of any height) and width less than that of the single slit central maximum;

one secondary maximum (at approximately $\pm 2.1 \times 10^{-3}$ rad) within the enveloping single slit pattern;

[2]