Option B — Quantum physics and nuclear physics

B1. This question is about atomic energy levels.

(a) Explain how atomic spectra provide evidence for the quantization of energy in atoms. *[3]*

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(b) Outline how the de Broglie hypothesis explains the existence of a **discrete** set of wavefunctions for electrons confined in a box of length *L*. *[3]*

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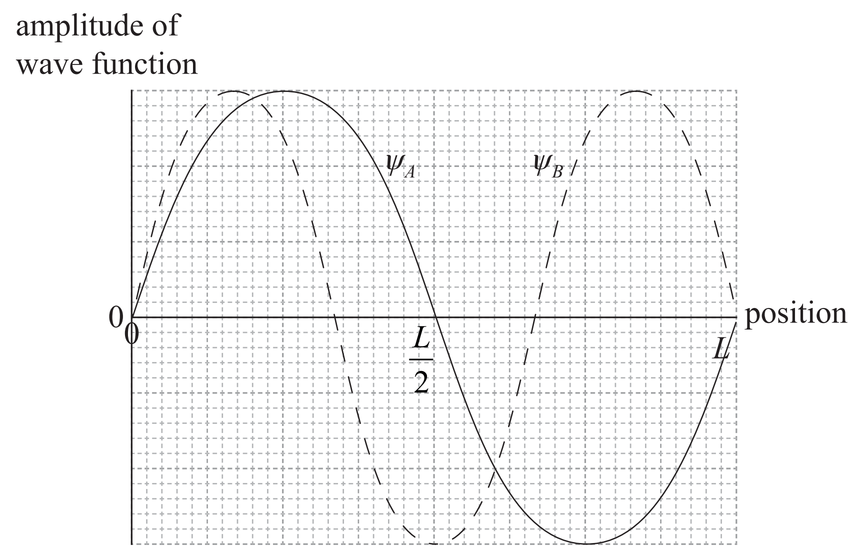
(This question continues on the following page)

(Question B1 continued)

(c) The diagram below shows the shape of two allowed wavefunctions ψ_A and ψ_B for an electron confined in a one-dimensional box of length L.



(i) With reference to the de Broglie hypothesis, suggest which wavefunction corresponds to the larger electron energy. *[3]*

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(Question B1 continued)

(ii) Predict and explain which wavefunction indicates a larger probability of finding the electron near the position $\frac{L}{2}$ in the box. *[2]*

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(iii) On the graph in (c) on page 7, sketch a possible wavefunction for the **lowest** energy state of the electron. *[1]*

Option B — Quantum physics and nuclear physics

B1. (a) atomic spectra have discrete line structures / only discrete frequencies/wavelengths;
photon energy is related to frequency/wavelength;
photons have discrete energies;
photons arise from electron transitions between energy levels;
which must have discrete values of energy; ***[3 max]***

(b) de Broglie suggests that electrons/all particles have an associated wavelength;
this wave will be a stationary wave which meets the boundary conditions of the box;
the stationary wave has wavelength $\frac{2L}{n}$ (where L is the length of the box and where n is an integer); ***[3]***

(c) (i) wavelength of ψ_A larger than ψ_B;
therefore momentum of ψ_B larger than ψ_A (from de Broglie hypothesis);
therefore ψ_B has larger energy; ***[3]***

or

ψ_B has $n = 3$, ψ_A has $n = 2$;
$E_K \propto n^2$;
so ψ_B corresponds to the larger energy;

(ii) $\psi_A = 0$, $\psi_B \neq 0$ in the middle of the box/at $\frac{L}{2}$;
so ψ_B corresponds to the larger probability since probability $\propto |\psi|^2$;
Accept $\propto \psi^2$. ***[2]***

or

the probability (of finding the electron) is related to the amplitude;
amplitude of ψ_B is greater than amplitude of ψ_A so ψ_B is more likely to be found;