(c) Figure 1(a) shows the wavefunction $\psi_0(x)$ of the particle when it has its lowest possible energy, i.e. when it is in its ground state. Figure 1(b) shows the wavefunction $\psi_5(x)$ of the fifth excited state. In each case, the classical amplitude for the particle oscillating with the corresponding energy has been indicated by vertical lines. The distance scale is the same in the two figures.

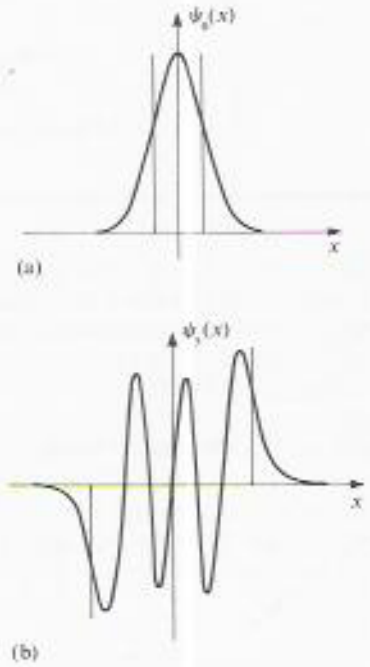


FIGURE 1

(i) For each wavefunction, sketch a graph to show the probability $P_n(x)$ that the oscillating particle will be detected in a small interval δx located at position x. State how the probability $P_n(x)$ is related to the corresponding wavefunction $\psi_n(x)$. *(7 marks)*

(ii) By referring to your sketches in part (i), state two similarities and two differences between the quantum mechanical description of the oscillating particle and the classical description that you met in Unit 6. *(6 marks)*

Question 3

This question relates to Unit 15 and carries 37% of the marks for this assignment.

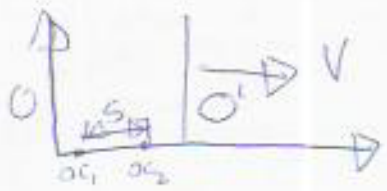
(a) How many different quantum states of an electron in a hydrogen atom correspond to the energy level with principal quantum number $n = 8$? Indicate your reasoning by *listing* the quantum numbers of the states. (Your answer should allow for the fact that the quantum state of an electron depends on its spin magnetic quantum number m_s.) *(7 marks)*

(b) Explain how the terms 'shell' and 'subshell' are related to the quantum numbers of an electron in a heavy atom. *(4 marks)*

(c) Describe briefly the principles and rules that govern the way in which the electron energy levels of an atom of an element in the Periodic Table fill with electrons as the atomic number of the element increases. *(8 marks)*

(d) Explain in a few sentences how the *group* and *period* of an element in the Periodic Table are related to its electronic structure. *(4 marks)*

(e) Chromium (Cr) and palladium (Pd) have atomic numbers 24 and 46 respectively. Write down the electronic structures of the ground states of these elements in standard notation and in box notation. Show explicitly how your answers follow from the rules outlined in part (c). *(14 marks)*



$S > c(t_2 - t_1)$.

$x_1 = 0 \quad x_2 = S$

$V = v$

$t_1 = 0 \quad t_2 = t$

$t' = \dfrac{t - Vx/c^2}{\sqrt{1 - V^2/c^2}}$

$t' = \dfrac{0 - VS/c^2}{\sqrt{1 - V^2/c^2}} = -$

$t_2' = \dfrac{t - VS/c^2}{\sqrt{1 - V^2/c^2}}$

$ct^2 - VS \geq 0.$