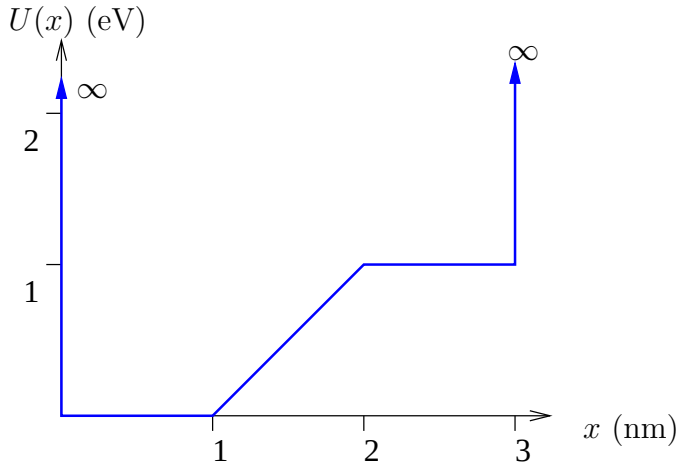
PC2232: Tutorial Homework Assignment 2

Due date: Wednesday, 16 April 2014

Question 1:

The graph below shows the potential energy function $U(x)$ of a particle. Solution of the Schrödinger equation finds that the $n = 3$ level has $E_3 = 0.50$ eV and that the $n = 6$ level has $E_6 = 2.00$ eV.



(a) Redraw this figure and add to it the energy lines for the $n = 3$ and $n = 6$ states.

(b) Sketch the $n = 3$ and $n = 6$ wave functions. Show them as oscillating about the appropriate energy lines. The sketches should be reasonably accurate with important features carefully illustrated.

Question 2:

Which of the following pairs of energy and magnitude of orbital angular momentum are possible for a hydrogen atom? For those that are possible, to what n and l values do they correspond? For the rest, explain why they are not possible.

(a) -0.544 eV, 3.655×10^{-34} J s

(b) -1.51 eV, 3.655×10^{-34} J s

(c) -1.51 eV, 2.110×10^{-34} J s

(d) -3.4 eV, 1.492×10^{-34} J s

Question 3:

Consider the wave function of one of the $3p$ states of hydrogen:

$$\psi_{310}(r,\theta,\phi) = \frac{2\sqrt{2}}{27\sqrt{\pi}a_0^{3/2}} \mathrm{e}^{-r/3a_0} \left(\frac{r}{a_0} - \frac{r^2}{6a_0^2}\right) \cos\theta, \tag{1}$$

where a_0 is the Bohr radius.

(a) Write down the radial probability density $P(r) = r^2 \left|R(r)\right|^2$ for this state.

(b) Identify the values of r that represent the minima in $P(r)$.

(c) Find the values of r that represent the maxima in $P(r)$. Hence determine the most probable position of the electron in this state.