

Use: $\hbar^2/2m_e = (\hbar c)^2/2m_e c^2 = (1973\text{eV}\text{\AA})^2/(2 \times 511,000\text{eV}) = 3.81\text{eV}\text{\AA}^2$, m_e =electron mass. **Use a new bluebook. Show all the steps necessary to find the answers.**

Problem 1 (10 pts)

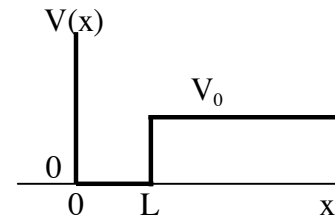
An electron is in a stationary state of an infinite square well that extends from $x=0$ to $x=12\text{\AA}$. It is four times as likely to be found at $x=3\text{\AA}$ as at $x=7\text{\AA}$.

- Find the energy of this electron (in eV), assuming it is in the state of lowest energy that has this property. Justify your answer.
- What is the probability to find this electron in the interval $0 < x < 3\text{\AA}$?
- Find the wavelengths (in \AA) of all the photons that this electron can emit by making transitions from this state to other stationary states in this well. Take into account the electric dipole selection rule.

Problem 2 (10 pts)

An electron is in a stationary state of the potential $V(x)$

shown in the figure: $V(x) = \infty$ for $x < 0$
 $V(x) = 0$ for $0 < x < L$
 $V(x) = V_0$ for $x > L$.



Its energy is 4 eV.

- Find its wavefunction in the region $0 < x < L$ for any value of V_0 , except for a normalization constant.
 - How much more likely is it to find the electron at $x=1\text{\AA}$ than at $x=0.5\text{\AA}$?
 - Find the smallest possible value of L (in \AA) assuming $V_0=10^{10}\text{eV}$.
 - Find the second smallest possible value of L (in \AA) assuming $V_0=10^{10}\text{eV}$.
 - Find the smallest possible value of L (in \AA) assuming $V_0=385\text{eV}$.
 - Find the second smallest possible value of L (in \AA) assuming $V_0=385\text{eV}$.
- Hints: (i) Note that because 385 eV is much larger than 4 eV, your answers for (c) and (d) should not be very different from your answers for (a) and (b). (ii) Keep in mind that calculators don't always tell you what you want to know.

Problem 3 (10 pts)

An electron is described by the wavefunction

$$\psi(x) = Cxe^{-\lambda x^2} \text{ with } \lambda = 0.5\text{\AA}^{-2}.$$

- Find the numerical value of C .
- Find $\frac{\partial^2 \psi}{\partial x^2}$ and insert it into the time-independent Schrodinger equation to find the most general form for the potential $V(x)$ in which this electron is moving. Show all steps in the derivation.
- What is the difference in the potential energy of this electron at positions $x=0$ and $x=1$? Give your answer in eV.
- Assuming $V(x=0)=0$ find the energy of this electron, in eV.
- Find the wavelengths of all the photons that this electron can emit, in \AA .
- Find the uncertainty in the position of this electron, Δx .
- Find the uncertainty in the momentum of this electron divided by \hbar , i.e. $(\Delta p/\hbar)$.
- Verify that the uncertainty principle is satisfied.

Use: $\hbar^2/2m_e = (\hbar c)^2/2m_e c^2 = (1973\text{eV}\text{\AA})^2/(2 \times 511,000\text{eV}) = 3.81\text{eV}\text{\AA}^2$, m_e =electron mass. Use a new bluebook. Show all the steps necessary to find the answers.

Continue in the same bluebook in class. The questions to answer are in bold

Problem 1 (10 pts)

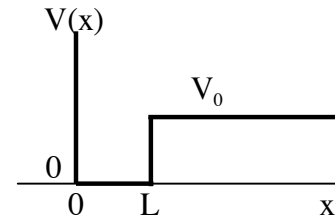
An electron is in a stationary state of an infinite square well that extends from $x=0$ to $x=12\text{\AA}$. It is four times as likely to be found at $x=3\text{\AA}$ as at $x=7\text{\AA}$.

- (a) Find the energy of this electron (in eV), assuming it is in the state of lowest energy that has this property. Justify your answer.
- (b) What is the probability to find this electron in the interval $0 < x < 3\text{\AA}$?
- (c) Find the wavelengths (in \AA) of all the photons that this electron can emit by making transitions from this state to other stationary states in this well. Take into account the electric dipole selection rule.
- (d) Find the wavelengths (in \AA) of all the photons of wavelength $> 2000\text{\AA}$ that this electron can absorb by making transitions from this state to other stationary states in this well. Take into account the electric dipole selection rule.

Problem 2 (10 pts)

An electron is in a stationary state of the potential $V(x)$

shown in the figure: $V(x) = \infty$ for $x < 0$
 $V(x) = 0$ for $0 < x < L$
 $V(x) = V_0$ for $x > L$.



Its energy is 4 eV.

- (a) Find its wavefunction in the region $0 < x < L$ for any value of V_0 , except for a normalization constant.
- (e) Find the smallest possible value of L (in \AA) assuming $V_0 = 385$ eV.
- (f) Find the second smallest possible value of L (in \AA) assuming $V_0 = 385$ eV.
- (g) Find the third smallest possible value of L (in \AA) assuming $V_0 = 385$ eV (for which an electron in this potential well can have energy 4eV).**
- (h) Assuming $V_0 = 385\text{eV}$, what is the smallest possible value of L (in \AA) for which there can be an electron in this potential well? What would be the energy of that electron in that case?**

Problem 3 (10 pts)

An electron is described by the wavefunction

$$\psi(x) = Cxe^{-\lambda x^2} \text{ with } \lambda = 0.5\text{\AA}^{-2}.$$

- (a) Find the numerical value of C .
- (b) Find $\frac{\partial^2 \psi}{\partial x^2}$ and insert it into the time-independent Schrodinger equation to find the most general form for the potential $V(x)$ in which this electron is moving. Show all steps in the derivation.
- (d) Assuming $V(x=0)=0$ find the energy of this electron, in eV.
- (i) At which position x is this electron most likely to be found?**
- (j) What would be the classical amplitude of oscillation for an electron with this energy in this potential?**