Chem 4A Lecture 05: Matter Waves
QM Particle in Box

9/8/2008

Light Wave/Particle Duality
Wave (length, frequency)  Particle (Momentum)

\[ \lambda = \frac{h}{p} \]
\[ E = h\nu = \frac{hc}{\lambda} \]
\[ E = mc^2 = pc \]
\[ p = h/\lambda \]

Matter Particle/Wave Duality (de Broglie)

Momentum

\[ e^- \rightarrow p = mv \]

Particle

Wave

\[ \psi^2 \sim \text{Probability} \]
\[ \lambda = \frac{h}{p} \]
\[ h = 6.62 \times 10^{-34} \text{ Js} \]

Diffraction and Interference

Intensity

\[ A + B \]

Probability Distribution

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De Broglie Wavelengths

<table>
<thead>
<tr>
<th>Particle</th>
<th>de Broglie $\lambda$ (nm)</th>
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<tbody>
<tr>
<td>Photon (yellow)</td>
<td>$\sim 600$</td>
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<tr>
<td>$e^-$ ($v \sim 10^5$ m sec$^{-1}$)</td>
<td>$\sim 6$</td>
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<tr>
<td>Na (80K, $v \sim 300$ m sec$^{-1}$)</td>
<td>$\sim 0.06$</td>
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<tr>
<td>Baseball (170g, $v \sim 40$ m sec$^{-1}$)</td>
<td>$\sim 6 \times 10^{-26}$</td>
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About how many photons should be able to ~stop the Na atom?

A) $\sim 1$  
B) $\sim 10^2$  
C) $\sim 10^4$

Particle in a Box

\[ \frac{h^2}{2m} \frac{d^2\Psi}{dx^2} + V\Psi = E\Psi \]

\[ \psi_n(x) = \frac{1}{\sqrt{L}} \sin \left( \frac{n\pi x}{L} \right) \]

\[ E_n = \frac{n^2h^2}{8mL^2} \]

E  n  Nodes

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<tbody>
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Which transition \( n_1 \rightarrow n_2 \) absorbs a photon with the highest energy?

A) \( 1 \rightarrow 2 \)  B) \( 2 \rightarrow 3 \)  C) \( 4 \rightarrow 2 \)

Absorption and Emission Spectra
Atomic and Molecular Transitions

\[ \Delta E = h\nu \]

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Shown is an energy-level scheme and the emission spectrum. Which line arises from \( 3 \rightarrow 1 \)?

A) A  B) B  C) C
ChemQuiz® 5.4

To which energy-level scheme does the full emission spectrum correspond?

A) B) C)