

Name: _____

Particle in a box: $\Psi_n = (2/L)^{1/2} \sin(\pi n x / L)$ $E = h^2 n^2 / 8 m L^2$

True/False and Multiple Choice Questions -

Answer both questions, showing all calculations, 15 pts each.

- Which of the following is not a requirement for wavefunctions?
A) wavefunction must be continuous B) wavefunction must be finite (no singularities)
C) wavefunctions must be normalized D) wavefunctions must be orthogonal
E) wavefunctions must be real
- Identify the following statements as true or false:
A) Blackbody radiation is negligible at high frequency because the excited energy levels are unpopulated.
B) The energy levels for the rigid rotor are evenly spaced.
C) The energy levels for the particle in a box are spaced quadratically.
D) The x and y components of the angular momentum for a particle may not be known simultaneously.
E) The x and y components of the linear momentum for a particle may not be known simultaneously..

Problems - Answer any 4 questions, showing all calculations 30 pts each

- Normalize the following wavefunction in the region from $x = 0$ to $x = 6$, $\Psi = A \cos \pi x$?
- Calculate the most probable displacements for the first excited state of the harmonic oscillator.

$$\Psi = N (2 x / a) \exp(-x^2 / 2a^2)$$

- What is the probability of finding an electron from 0.0 \AA to 1.0 \AA in the second excited state ($n = 3$) for a particle in a 5.0 \AA box?
- Suppose a particle of mass $10 \times 10^{-27} \text{ kg}$ is rotating about a fixed point $2 \times 10^{-10} \text{ m}$ away. Calculate the lowest energy rotational transition for this system.
- Determine which of the following functions are eigenfunctions of the inversion operator (in which x becomes $-x$, assuming k is a real number in all cases). Calculate the eigenvalue for these operators.
a) $x^3 - kx$ b) $\sin(kx)$ c) $x^2 + 3x - 1$ d) $\exp(-(x+k)^2)$
- Draw a potential energy surface which can exhibit tunneling behaviour. Indicate the energy of a trial wavefunction drawn on the diagram which exhibits tunneling.
- Show graphically how the three lowest energy wavefunctions would change if the potential energy for a particle in a box (with infinite potential at $x = 0$ and L) were to vary linearly across the range ($V = kx$ from $x = 0$ to L and that $kL < E_1$).