

## 2130 Learning Goals – Draft 3: 12/8/06

1. wave function and probability
  - Explain how the wave function description of matter replaces the particle description of matter.
  - Determine a potential energy diagram from a physical situation and vice versa.
  - Recognize that quantum mechanics describes the world using an energy picture rather than a force picture.
  - Predict where a particle is most likely to be, given a wave function.
  - Predict the energy that a particle is most likely to have, given a wave function.
  - Apply the definitions of amplitude, wavelength, frequency for classical and quantum waves.
  - Determine reflection and transmission coefficients for classical and quantum waves.
2. wave-particle duality
  - Recognize that matter is described by wave functions, not by particles moving along trajectories.
  - Recognize that the wave function, via the Schrodinger Equation, describes the entire dynamics of matter, but cannot be measured.
  - Recognize that light is described by electromagnetic waves.
  - Compare and contrast the behavior of electromagnetic waves and matter waves.
  - Recognize that light comes in discrete energy packets.
  - Explain how the photoelectric effect experiment proves that light comes in discrete energy packets.
  - Describe how energy quantization results from boundary conditions on wave functions or other kinds of waves.
  - Determine when to use wave picture and when to use particle picture and recognize that it is not random.
  - Describe how the wave picture of electrons leads to quantization of energy levels in atoms.
  - Recognize that “Which slit did the particle go through?” in a double slit experiment is a trick question.
3. Schrodinger Equation
  - Motivate the Schrodinger Equation from conservation of energy.
  - Solve the Schrodinger Equation for simple potentials.
  - Sketch solutions to the Schrodinger Equation for arbitrary potentials.
  - Use the Schrodinger Equation to describe tunneling and radioactive decay.
  - Calculate reflection and transmission coefficients, and determine how these change with width and height of barrier.
  - Describe how the solutions to the Schrodinger equation explain the shape of orbitals of atoms.
  - Describe how the solutions to Schrodinger explain the numbers of electrons in each shell of an atom.
4. quantization of energy/quantum numbers/unique states
  - Recognize that things can exist only in certain discrete states; not all values of energy, angular momentum, spin, etc. are possible.

- Describe how this quantization results from wave nature of matter.
  - Recognize that when things exist in certain energy states, they take on certain probability distribution functions.
  - Describe how quantization explains the structure of the periodic table.
  - Predict occupancy of states based on the Pauli Exclusion Principle.
  - Calculate the energies of photons emitted in transitions.
5. uncertainty principle
- Recognize that a particle in an energy or momentum eigenstate is spread out in space.
  - Recognize that a localized particle does not have a well-defined energy or momentum.
  - Recognize that the uncertainty principle describes a fundamental indeterminacy, not just something that we don't know.
  - Describe how the uncertainty principle results from probabilistic interpretation of wave function.
6. superposition
- Recognize that a system can be in superposition of eigenstates, and is not necessarily always in an eigenstate.
  - Predict possible outcomes of a measurement of a superposition state.
7. operators and observables
- Predict with what probability a certain value of an observable will be measured.
8. measurement
- Determine how a quantum mechanical system changes upon measurement.
  - Recognize that this behavior is NOT simply because a measurement "disturbs the system."
  - Recognize that "What was the energy before you measured it?" is a trick question.
  - Recognize that a measurement is simply an interaction with something external to the system.
  - Explain why and how measuring which slit the particles go through in a double slit experiment destroys the interference pattern.
  - Recognize that an eigenstate is what you get when you make a measurement, not necessarily the state that things are always in.