**Modern Physics – Exam 3 – Learning Goals**

The wave function – understand the relationships between amplitude and probability; wavelength and momentum (and therefore kinetic energy); total energy and frequency. How the uncertainty principle (position and momentum) is explained in terms of wave packets and plane waves. In other words, what does this wave function represent and what kinds of information does it contain?

Schrödinger equation – know what solutions are in regions where the potential energy is constant (whether zero or non-zero) and when total energy is greater and less than potential energy.

Free particle (zero potential) – know solutions for the case when potential is zero, and all the usual wave relationships (wavelength, wave number, frequency, angular frequency, direction of propagation).

Infinite square well potential – be able to relate to physical situation (when it can be used to model the potential of an electron in a wire), know how specific solutions result from the relevant boundary conditions and what those solutions look like, know energy levels, and how those change when the dimensions of the wire change.

Finite square well potential – be able to relate to physical situation (when it can be used to model the work function of a metal), understand what the boundary conditions are on the wave function, and how those solutions match at the boundaries. Be able to explain (mathematically and in words) how the wave function decays in a classically forbidden region, and how this relates to the probability for tunneling.

Tunneling – know what factors increase the probability for tunneling, which will decrease this probability, and which have no effect.

Alpha-decay – relate quantum tunneling to alpha-decay, and understand the relationship between the probability for tunneling and the radioactive decay lifetime.

STM’s – be able to explain how a scanning tunneling microscope works, why there needs to be a potential difference between sample and tip, and how hooking up a battery changes the potential energy curve for an electron in the tip, sample, and in the gap in between.

Hydrogen atom – know the basic shapes of the orbitals, and how each corresponds to different quantum numbers; know how energy is related to these quantum numbers. Know the restrictions on what quantum numbers are allowed, and how many wave functions correspond to given quantum numbers. Also, know how many electrons can fit in an orbital, and how this is related to electron spin and the periodic table. Be able to compare the Schrodinger, Bohr and de Broglie models (what they got right, and what they got wrong).

Multi-electron atoms/periodic table – understand how the energies for atomic orbitals change due to charge shielding, and be able to explain how the shapes of orbitals correspond to different kinds of shielding. Understand that similarly shaped orbitals with similar energies lead to similar chemical behavior, which explains the periodicity of the elements.

Relevant sections in Thornton and Rex, Modern Physics for Scientists and Engineers:

Wave motion: 5.4 pp. 174-181

Wave function, uncertainty principle, probability: 5.5-5.7 pp. 181-193

Schrodinger equation and expectation values: 5.1-5.2 pp. 201-210

Infinite square well: 5.8 pp. 193-195; 6.3 pp. 211-215

Finite square well: 6.4 pp. 215-217

Barriers and tunneling: 6.7 pp. 225-231 (includes alpha-decay)

STM’s: pp. 232-233

Hydrogen atom: Chapter 7, pp. 239-265

Atomic structure and periodic table: 8.1 pp. 268-275

**IMPORTANT INFORMATION that you may need:**

Speed of light in empty space (c) 

Planck’s constant (h) 

 

Charge of an electron (-e) 

Mass of an electron (me) 

Ground state energy of electron 

in Hydrogen

Mass of proton (mp) 

  

Representative wavelengths: Red (680 nm); Orange (610 nm);

Yellow (580 nm); Green (540 nm); Blue (470 nm); Violet (410 nm)



1-D Time-Dependent Schrödinger Equation



deBroglie Relation:



Energy of a photon:

