Subject and Problems:

EXM=exam 2, PT = practice test 2, HW=homework, Ex= example from book, PF=practice final

1. Understand solid angles and how they are used when describing scattering. The Rutherford experiment is a prototype. EXM3, PT4, HW5: 4.8, 3, 4, PF
2. Use and derive the Bohr model and generalization. Especially important for estimates: EXM1, PT 1, PT2, HW6: all – for example 2,3,4, PF
3. Debroglie waves, wave packets, and the uncertainty principle. HW7: 1 , HW7 3.19, 3.28, 3.30, PF
4. Skills with wave functions:
   (a) Determine probabilities to find an electron in a region of space given the wave function HW7: 5.7
   (b) Determine the most likely position of finding an electron. HW7: 5.2
   (c) Normalize the wave function HW7: 5.10
   (d) Compute the average position, variance in position, average momentum and the variance in momentum. Determine the average kinetic energy and potential energy EXM2, many examples from HW7 and HW8
   (e) Show that this or that function obeys the time dependent or time independent Shrödinger equation and determine the energy in the time independent case. `HW7:5.10, HW8:2, PT3, Ex5.9, PF`
5. Qualitative features of the wave function:
   (a) Understand that the ground state is a balance between the kinetic and potential energies and that this provides an order of magnitude for the size HW8: 2, HW9 5.22, PT:2
   (b) Understand that in the classically allowed region the local wavelength is determined by the available kinetic energy, $k^2 \propto (E - V)$. HW9: 5.25, 5.27, 5.30, PT: 5
   (c) Understand that in the classically forbidden region one decreases exponentially as one goes deeper into the forbidden region, and increases exponentially as one goes out of the forbidden region. The rate is governed by $\Psi \propto e^{\pm\kappa(x-x_o)}$ where x_o is the classical turning radius, $\kappa^2 \propto (V - E)$ HW9: 5.25, 5.27, 5.30, PT: 5.
   (d) Understand that it is requiring that the wave function $\psi \to 0$ at $x \to \pm\infty$ that leads to discrete energies. see Lecture L19_slides
   (e) Describe qualitatively the $n-th$ excited state of a given potential. EXM2, HW9: 5.22, PF
6. Specific solutions to the Shrödinger Equation:
   (a) Know and the particle in the box wave functions and energies. e.g. EXM2, PT3, HW9, PF

(b) Know the energies associated with the harmonic oscillator and be able to use the table of harmonic oscillator wave functions given in class. If this table of wave functions is needed it will be provided. HW8: 2, HW9: 6.32, PF

7. Calculate the effect of a perturbing potential on the energies. HW9: 3, EXM2

8. For three dimensionsional with a spherically symmetric potential $V(r)$ – this concerns the radial part. PF, HW11

   (a) Know what the radial schrodinger equation is. Be able to graph the effective potential and qualitatively sketch the solutions (i.e. $u_{n\ell}$ or R_{nl}) for different ℓ. Be able to show that this or that wave function satisfies the radial Schrödinger Equation HW

   (b) Know how the radial probability distribution $P(r)dr$ is related to u_{nl} and R_{nl} and be able to graph for the wave functions of hydrogen. Be able to calculate various quantities like the average potenial energy, average radius, variance in radius, most likely radius. HW

9. For three dimensionsional with a spherically symmetric potential $V(r)$ – this concerns the angular part. PF,HW12

   (a) Know that the angular probability distribution is P_Ω is $|\Theta_{lm}|^2/4\pi$ and what this means.

   (b) Explain using the hydrogen wave functions why close shells effectively screen the nuclear charge.

   (c) Be able to graph (polar plot or regular plot) the angular probability distribution functions for s and p and d waves for different m.

   (d) Be able to calculate the probability to find the electron in a given cone or determine the normalization constant of the wave function Θ_{lm}

10. Hydrogen wave function and the periodic table. PF, HW11, HW12

    (a) Be able to list the electronic structure of an element given the atomic number Z. Be able to explain the basic properties of the periodic table.

    (b) Know how the energies, squared angular momentum momentum, and component of z angular momentum is related to the quantum numbers n, ℓ, m

    (c) For a given n be able to list the allowed values of ℓ and m etc.

Specific Mathematical Skills we have developed:

1. Know a few Taylor series and how to use. For this test $\sin(x), \cos(x), \exp(x), (1+x)^\alpha$ should do it. This will appear in some (probably minor) way.

2. Know that products of sin's and cos's can be written as sums of sin's and cos's. This is clear if you use complex exponentials instead of sin's and cos's. We used this in several ways: analyzing beats, to do integrals involving the particle in the box. HW7: 1,

3. Understand complex numbers: Quiz that never happened, HW7: 2