Review for Exam 2
Phys 402

Background

Modern Physics Concepts
The Postulates of Quantum Mechanics

The infinite square well potential
The harmonic oscillator

Hydrogen

The Hydrogen Atom (Lecture 1)
- Quantum numbers n, ℓ, m_ℓ
- Eigen-energies $E_n = -13.6\ eV/n^2$, degeneracy $p = 2n^2$ (including spin)
- Eigen-functions (Spherical Harmonics, radial solution)
- Orbital angular momentum as a ladder of states
  - Raising and lowering operators ($\hat{a}_\pm, \hat{L}_\pm, \hat{S}_\pm, \hat{J}_\pm$)
  - Top and bottom of the ladder
  - Symmetric about 0
- Internal field, spin-magnetic field interaction potential $\mathcal{H}^1 = -\vec{\mu} \cdot \vec{B}$

Spin-1/2 (Lecture 2)
- "A two-valudeness not describable classically"
- Spinor Kets $|s\ m_s\rangle$, Pauli spin matrices

Important Skills and Concepts

Adding Vector Operators $\vec{J} = \vec{L} + \vec{S}$ (Spin-orbit, Lecture 5), $\vec{L} + \overrightarrow{2S}$ (Zeeman, Lecture 9), $\vec{S} = \vec{S}_1 + \vec{S}_2$ (Hyperfine, Lecture 7)

Going back and forth between the Coupled and Un-Coupled Representations

$$\left| j\ m_j \right\rangle = \sum_{m_\ell + m_s = m_j} C^{\ell\ \ s\ \ j}_{m_\ell\ m_s\ m_j} \left| \ell\ m_\ell \right\rangle \left| s\ m_s \right\rangle$$ (Lecture 6)

Spin-triplet and spin-singlet states for two spin-1/2 particles

Perturbation Theory
- Time-Independent, Non-Degenerate, 1st-order, 2nd-order (Lecture 3, Lecture 4)
- Time-Independent, Degenerate (Lecture 8)

Multi-Identical Particle Wavefunctions

Bosons and Fermions [anti-symmetry constraint], Pauli Exclusion Principle, He atom (Lecture 10)
- Exchange energy, Helium ground and excited states (Lecture 11)
- H_2 molecule (Lecture 12)

Time-Dependent Perturbation Theory

Transition probability from time-dependent perturbation, two-level systems (Lecture 13)

Sinusoidal perturbations, Rabi oscillations (Lecture 14)

Selection rules (Lecture 15)

Incoherent absorption of light, LASERs (Lecture 16)

Approximation Methods

WKB for classically-allowed potentials, eigen-energies and eigen-functions (Lecture 18)

WKB for classically-forbidden regions – Tunneling (Lecture 19)

The Variational method for finding ground state energies (Lecture 20)

Best way to study for the exam?

Do all the homework problems "cold turkey"

Solutions posted on ELMS!

Understand the concepts (combining vector spins, employing the postulates, respecting indistinguishability,…)

Be proficient at the skills (expectation values, perturbation theory,…)