Preparation for Exam

Instructions

The exam will begin at 7pm on Tuesday, November 26 in room MPHY 203.

The exam will consist of 20 multiple choice questions. You will have 60 minutes to complete the exam. A formula sheet with the basic fundamental equations and important constants will be provided on the exam. An example of this sheet is given at the end of this document. Additionally, you may bring a single, 1.5 pages sheet (standard US letter size or smaller) with your own notes or helpful formulas written on it.(The amount of notes which can be brought will be increased by half a page per exam, i.e. half page for exam 1, full page for exam 2, one and a half for exam 3, 2 pages for the final exam) These sheets will be inspected before the exam starts. You will be required to show your student ID on submission.

Note: In the event that you are unable to take the exam at the scheduled time, or an external event beyond your control interferes with your ability to take the examination, you ***MUST*** notify me as soon as possible so that alternate arrangements can be made (within reason).

Recommendations for studying

- Study chapters 7, 8, 12, 15.
- Review lectures 11 - 14.
- Review hw assignments 7-9.
- A calculator is highly recommended

Preparation for Exam

Outline of study

- General form of the Schrodinger Wave Equation
  - o $$\Psi(x,t) = Ae^{i(kx-\omega t)} = A[\cos(kx-\omega t) + i\sin(kx-\omega t)]$$
- Normalization & Probability
  - o $1 = \int_{-\infty}^{\infty} \psi^*_{(x)} \psi_{(x)} dx$
    - ▪ The bounds can also be finite if x can only exist in a fixed area.
  - o $P = \int_{x_1}^{x_2} \psi^*_{(x)} \psi_{(x)} dx$
- Boundary Conditions for Wave Equations
  - o In order to avoid infinite probabilities, the wave function must be finite everywhere.
  - o In order to avoid multiple values of the probability, the wave function must be single valued.
  - o For finite potentials, the wave function and its derivative must be continuous. This is required because the second-order derivative term in the wave equation must be single valued. (There are exceptions to this rule when *V* is infinite.)
  - o In order to normalize the wave functions, they must approach zero as *x* approaches infinity.
- Time-Independent Schrodinger Equation
  - o $$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x)$$
- What is an expectation value and how to find it
  - o $E(X) = \int_{-\infty}^{\infty} \psi^*_{(x)} \, X \, \psi_{(x)} dx$

Preparation for Exam

- The various Operators & how to use them
  - Position: $\hat{x} = x$
  - Momentum: $\hat{p} = -i\hbar\frac{\partial}{\partial x}$
  - Energy: $\hat{E} = i\hbar\frac{\partial}{\partial t}$
  - Hamiltonian: $\hat{H} = \frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + v_{(x)}$
- Solutions to 1-D Infinite and Finite Square Wells
- Degeneracy
  - Degeneracy is when multiple wave functions have the same energy.
- Simple Harmonic Oscillator
- Purpose of Radial and Angular Equations
  - $R_{n,l}(r)$
  - $Y_{l,m}(\theta,\varphi)$
- Quantum Numbers, what they represent, and their Boundary Conditions
  - $n = 1, 2, 3, 4, \ldots$ Integer
  - $\ell = 0, 1, 2, 3, \ldots, n-1$ Integer
  - $m_\ell = -\ell, -\ell+1, \ldots, 0, 1, \ldots, \ell-1, \ell$ Integer
- What is the Normal Zeeman Effect
- Intrinsic Spin
  - $m_s = \pm\frac{1}{2}$
- Selection Rules
  - Δn = anything
  - $\Delta\ell = \pm 1$

- $\Delta m_l = \pm 1, 0$

- Inverse Photoelectric effect
- Electron Filling & Pauli Exclusion Principle
- Total Angular Momentum
  - **J** = **L** + **S**
  - $$L = \sqrt{\ell(\ell+1)}\hbar$$ $$S = \sqrt{s(s+1)}\hbar$$ $$J = \sqrt{j(j+1)}\hbar$$
- Spin-Orbit Coupling
- Hund's rules
  - The total spin angular momentum *S* should be maximized to the extent possible without violating the Pauli exclusion principle.
  - Insofar as rule 1 is not violated, *L* should also be maximized.
  - For atoms having subshells less than half full, *J* should be minimized.
- Anomalous Zeeman Effect
- Applications of Hund's rules (aka, how to find the state of a valance electron)
- What an isotope is
- Fermi Distribution
  - $$\rho(r) = \frac{\rho_0}{1 + e^{(r-R)/a}}$$
- Intrinsic Magnetic Moment
- Nuclear Forces
- Liquid Drop Model
- Nuclear Shell Model

Preparation for Exam

- Radioactive Decay
    - Alpha
    - Beta
    - Gamma
- Determining Ages
- Stellar Evolution
- General Relativity
    - The principle of Equivalence in General relativity: There is no experiment that can be done in a small, confined space that can detect the difference between a uniform gravitational field and an equivalent uniform acceleration.
- Gravitational Time dilation
- Gravitational Waves
- Black Holes
- Conservation Laws
- Schwarzschild Radius
    - $r_s = \frac{2GM}{c^2}$
- Equivalence of Mass and Energy
    - $E = mc^2$
- Hawking Radiation
    - $T = \frac{\hbar c^3}{8\pi kGM}$