CHEM 221A - ADVANCED QUANTUM MECHANICS (3 UNITS)

COURSE OVERVIEW

SUMMARY

Chem 221A is a graduate level quantum mechanics course designed to introduce first or second year graduate students in physical or theoretical chemistry to advanced quantum mechanics as applied in modern physical chemistry. The course assumes a good working knowledge of linear algebra and calculus, as well as at least one semester of intermediate quantum mechanics at the undergraduate level. Material is presented in the course predominantly through lecture (3 hours a week) and an optional weekly discussion section. Your final grade is largely based off of exams (70%), with a contribution from weekly problem sets (30%).

PREREQUISITES

Formal: Graduate standing, chem 120A/B, or consent of instructor.

Notes: Chem 120B is not particularly important for this course, but chem 120A is a hard requirement

TOPICS COVERED

- Linear algebra review
  - Hilbert spaces
  - Important theorems

- Quantum states and operators
  - Dirac notation
  - Matrix representation of operators
- Topics on Hilbert spaces
  - Continuous and discreet spaces
  - Bound and free particle wavefunctions
  - Position/momentum representations
  - The Dirac delta function
  - Closure
- Operators
  - Representations
  - Eigenvalues and eigenfunctions
  - Spectral decomposition
  - Unitary, self-adjoint, and inverse operators
  - Commutators
  - Uncertainty principle
- The Schrödinger equation
  - Time dependent and independent forms
- Quantum measurement
  - Density matrices
  - Dephasing
  - Entanglement
- Harmonic oscillator
  - Classical
  - Quantum, via ladder operators
  - Coherent states
  - Coupled oscillators
- Rotations on quantum states
  - Euler angles
  - Infinitesimal rotation operators
    - Angular momentum as a generator of rotation
  - Rotation matrices
- Angular momentum
  - Eigenvalues and eigenfunctions
  - Representations

    - Spin angular momentum
    - Orbital angular momentum
- Coupling of angular momenta
    - Counting states
    - Clebsch-Gordon coefficients
    - Wigner 3j-symbols
- Scalar and vector operators
    - Spherical tensors
    - Wigner-Eckart theorem
    - Projection theorem
- Approximation methods
    - Mean field
    - Time dependent and independent perturbation theory
    - Variational theory
- Spectroscopic models
    - Fermi's golden rule
    - Time energy uncertainty
    - Oscillatory perturbations

WORKLOAD

COURSEWORK

- Ten problem sets (30%)
- One midterm (30%)
- One final exam (40%)

TIME COMMITMENT

Problem sets easily take an entire day (8+ hours), and are quite challenging. Three hours of lecture per week, and one weekly 2 hour discussion (recommended, but optional).

CHOOSING THE COURSE

WHEN TO TAKE

After you have taken chem 120A/B, and feel comfortable with linear algebra. This course is demanding, and best taken during a light semester.

WHAT NEXT?

- Chem 221B (chem221b.html)

ADDITIONAL COMMENTS AND TIPS

This course is intensive, and you should be prepared to commit a large amount of time to it if you want to do well. The material is very thorough at expense of being very challenging.

Written by: Brighton Skeel

Last edited: Fall 2018