Final Study Guide

This is intended as a rough guide to let you know what topics I have tried to emphasize and am thus more likely to test on. When in doubt, go by what is in the lectures. If it isn't there, it won't be on the exam. If it is emphasized in the lectures, it is more likely to be on the exam. For the first 2/3 of material, everything that was fair game before still is, so I'm focusing on the new material since the second exam here.

- Optics
  - Reflection, Refraction, Transmission. Which is which, why each is relevant. The difference between specular and diffuse reflection.
  - Mirrors
    - Law of reflection, flat mirrors. Rays.
    - Real vs. Virtual images.
    - 2 types of spherical mirror. Which is which, be able to draw rays for each kind.
      - Why are parabolics better? Why don't we use them?
      - What is the point of assuming small spherical mirrors rather than large ones?
    - Converging vs. Diverging rays. Where do the images form?
    - Focal point, center point, radius of the mirror.
    - 3 ray process for locating an image given a mirror.
    - Mirror equation and how to calculate magnification.
  - Snell's Law. What it is, what it means for rays passing through an interface. Some real-world examples of how this comes up.
  - Dispersion. Why do colors separate?
  - Total Internal Reflection. Know how it follows from Snell's law and what it means.
  - Thin Lenses
    - Why thin? How does this relate to spherical mirrors being assumed to be small?
    - Terminology and definitions (focal points and so forth).
    - How to draw ray diagrams. How is Snell's Law important for lenses?
    - Lens equation and how to use it (but you don't need to know how it or the mirror eq. are derived).
    - Magnification.
- Light as Waves and Interference
  - Huygens' Principle. What it says and how to use it.
  - Diffraction. What is it, why does it happen, and why is it important? Be able to relate diffraction of waves with both optics and quantum mechanics.
  - Refraction. Only very basically what is going on, you don't need to be able to reproduce the logic for why it follows from Huygens' principle, but you should know that the wavefronts change direction at an interface just like rays do.
  - Interference. You should understand how interference works for a general wave. Specifically, why it can be both constructive and destructive. Know how this comes up with EM waves and so optical effects.
  - 2 slit experiment. You don't need to know the math, but be able to describe why we get an interence pattern.
- Early Quantum Mechanics
  - Know why blackbody radiation and the photoelectric effect don't make sense classically and led to ideas about the quantization of energy. Understand how the two were similar and different.
  - Wave-particle duality. Why is it weird, and why is it necessary? Be able to discuss some example which demonstrates that nature really does have this property and understand why that example means wave particle duality is real.
  - Be able to calculate a de Broglie wavelength and know what it means. Know how to interpret longer vs. shorter wavelengths (longer wavelengths give more obvious wave effects, more weird quantum behavior...)
  - 2-slit experiment for electrons

- Electron microscopes. Know why they can give greater resolution and what that has to do with quantum (de Broglie wavelength)
- Know enough about each of the early models of the atom that you could tell a friend (or possible an exam question) why each isn't quite right, but also why each is better than the previous.
- Know about the correspondence principle and why something like it has to be true.

- Modern Quantum Mechanics
  - Matter waves. Know about the probability density interpretation of the wave part of wave-particle duality. What does this mean for e.g. the electron 2-slit experiment? Why don't big objects diffract and whatnot?
  - Why doesn't this fit a classical picture? Why does, for example, the electron 2-slit experiment violate our intuitive assumptions about how objects behave?
  - Heisenberg Uncertainty Principle. What does it *really* mean? I went on a rant about this, thats a good hint I care and consider it important to understand (or at least know what about it you don't understand and what you aren't understanding) :)
  - Know that Schrödinger's equation can tell you what the "wavefunction" looks like, and what that means
    - What does this have to do with interference? (wavefunction can be + or - and is a wave, so...)
    - What does this have to do with probability? (ψ can be "squared" to give the probability density, which tells us the relative likelihood for finding a particle in various places)
    - What do I mean by "bound" and "free" particles? Given a potential with some height U_0, what energies will be bound by and which not? Can you relate this to some classical system? What is similar, what is not? When do they two start to look similar?
    - Why do wavefunctions keep getting smaller "inside the walls" of potential barriers, while they oscillate or peak between walls or where walls don't exist? The wavefunction leads to probability density, and walls contain objects. In QM, this means the probability for an object being deep in the wall is small.
    - Sometimes a particle is allowed to have any energy, and sometimes only certain energies. Why? How do you tell the difference?
    - Know about the different quantum numbers in the hydrogen atom solutions. They lead to orbitals, and tell us how many electrons you can have in each kind of orbital. Know how these numbers (2 Ss, 6 Ps, etc.) follow from the quantum numbers.
    - Pauli Exclusion is needed for the last point, but deserves its own mention.
    - What is the EPR thought experiment? Why is it freaky? (I now notice that the notes I posted aren't as complete as what I discussed in class. I'll remedy that today, but in the meantime those who weren't in class can see who took notes.)

- Bonds
  - Know how Covalent/Ionic bonds work. How do they relate to the quantum ideas above?
  - Be able to understand the potential energy diagram for a molecule. This means knowing where bound states are allowed, whether there is an activation energy, what that means, etc.
  - Know where Van der Waals forces come from.

- Solids
  - Metallic bonds. How are they similar to covalent bonds, how different?
  - Band theory. What are bands/gaps? How does their arrangement lead to various properties of a metal?
  - Why are electrons less likely to flow when the highest occupied band is full? What can make this even harder, or easier, without partially filling a gap?

- Special Relativity
  - Understand where time dilation comes from and be able to calculate it given a relative velocity.
  - How does electricity and magnetism relate to SR? Mechanics needs modified to be consistent, with new definitions for momentum and energy and so forth. Why doesn't E&M?

Note that Nuclear Physics and Gravitation/Cosmology don't appear here, which means that you don't need to worry about the text after chapter 40.