What do I need to know for 3.024 Final 2013?

1. Schrodinger's equation – when can you use time-independent Schrodinger's equation

2. Particle in a box – solve from scratch.

3. Continuity of wavefunctions and their first derivatives at materials boundaries – piecewise potentials - solve from scratch.

4. Harmonic oscillator – Hamiltonian operator, energy eigenvalues, general form of eigenfunctions (you do not need to memorize Hermite polynomials, but you need to know what they are), orthogonality of eigenfunctions, even and odd eigenfunctions. Eigenfunction shapes.

5. Conservation - when is energy conserved, when is momentum conserved, when is angular momentum conserved.

6. Periodic potentials: what is and what is not conserved. Eigenfunction form for periodic potentials.

7. Graphic representation of simple periodic potentials (finite number of sines and cosines)

8. Band diagram shapes E vs k within the Brillouine Zone - Qualitative

9. Periodic potential eigenfunctions at the band edge (when $k = \pm g/2)$ - Qualitative

10. Band gap vs height of the periodic potential (quantitative), bandgap vs. size of atoms – Qualitative.

11. Direct vs Indirect band gap – qualitative. Absorption in semiconductors.

12. Effective mass approximation at the band edge. How does it convert periodic potential problem into a free particle problem

13. Density of states derivation for a free electron gas in 1D, 2D and 3D. What is density of states, how does it relate to the shapes of the bands, effective masses.

14. Fermionic nature of electrons. Antisymmetric wavefunctions for 2-electron system. Pauli exclusion principle.

15. Fermi function (= occupational probability) at different temperatures. Significance of the Fermi level. Fermi level as chemical potential.

16. Fermi level and D.O.S in intrinsic semiconductors.

17. Carrier concentration in intrinsic semiconductors. Using D.O.S. and Fermi distribution to find concentrations of electrons and holes.

18. Law of mass action.

19. Conductivity in semiconductors - what parameters determine conductivity. What is the difference in conductivity dependence on temperature in semiconductors vs. metals.

20. Doping. How does the number of dopants translate into carrier concentration. Minority and majority carriers.

21. Carrier concentration/conductivity dependence on temperature in doped semiconductors.

22. Fermi levels in doped semiconductors.

23. PN junction: built-in potential, depletion width. Dependence of the depletion width on the dopant concentrations.

24. PN diode: drift and diffusion currents under forward and reverse bias. Depletion width dependence on applied bias voltage. J-V characteristics.

25. Solar cells. J-V characteristics. Photocurrent and open circuit voltage. Power efficiency and fill factor.

26. LEDs. J-V characteristics. Turn-on voltage, spectra, power efficiency.

27. Connection between polarizability, dielectric displacement and electric field. Dielectric constant and permittivity. Real and complex parts of the permittivity as functions of frequency - their relation to refraction and absorption.

28. Wave equation for EM radiation. Speed of light and index of refraction.

29. Snell's law.

30. Total internal reflection. Waveguides, numerical aperture.

31. S and P polarizations. Reflection vs angle plots. Brewster angle.

32. Anti-reflection coatings.

33. Classification of magnets. Exchange energy and ordering.

34. Magnetic anisotropy energy. Hysteresis loops in ferromagnets. M vs. H for hard and easy axis magnetization. Dissipation of energy as heat during magnetization/demagnetization.

35. Magnetic domains. Calculation of the width of magnetic walls. When does material become single domain vs multi-domain.

36. Applications of soft and hard magnets.

3.024 Electronic, Optical and Magnetic Properties of Materials
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