CONTEMPORARY PHYSICS

The same study sheet will apply to both PHYS 451 & 452

Spring, 2008

To be prepared for the final exam on Monday, May 13 at 11:50 AM in CW 216, you should be able to:

1. List quantities which are conserved in an interaction;
2. Identify situations in which various conservation laws apply;
3. Apply appropriate conservation laws to an interaction, including radioactivity, fission and fusion;
4. Describe processes in which mass is converted to energy and vice versa;
5. Describe the concept of binding energy and how to determine it;
6. Determine the energy of a photon when given its frequency;
7. Describe similarities and differences among the light emitting characteristics of LEDs and incandescent lamps;
8. Describe the light spectra of LEDs, gas lamps, and incandescent lamps;
9. Explain the relation between the observed spectra and energy levels in a solids and gasses;
10. Construct an energy level diagram from the emission or absorption spectrum;
11. Use a given energy level diagram to construct the corresponding spectrum;
12. Apply conservation of energy to explain how the spectra of gases lead to the conclusion that only certain energies are available in an atom of a gas;
13. Apply the energy level model to explain the relationship between emission spectra and absorption spectra;
14. Explain why energy bands must be used to create a model of the emission of light from an LED;
15. Apply the energy band model to explain how light is emitted in LEDs and incandescent lamps;
16. Describe how adding impurities to a solid alters the energy bands in a semiconductor;
17. Describe the energy bands for a solid that consists of an n-type and p-type material;
18. Apply the energy band and gap model to explain the electrical characteristics of an LED;
19. Describe and explain the relation between threshold voltage and color of light emitted by an LED,
20. Summarize the energy level model, describe how it helps explain the light emission from solids and gases and gamma rays from nuclei and explain some of its limitations
21. Explain how interference patterns occur from addition of waves;
22. Explain why the observance of interference indicates that the object is behaving as a wave;
23. Apply addition of waves to determine an interference pattern;
24. Describe evidence that electrons must sometimes be described as waves;
25. Determine the wavelength of an object from its momentum;
26. Calculate the wavelength of an electron when given its kinetic energy;
27. Explain why macroscopic objects, such as people, do not demonstrate interference effects;
28. Describe how we interpret the amplitude of a wave associated with an electron, or other small object;
29. Explain why we connect the square of the wave function rather than the wave function with the probability density,

30. Determine the probability of an object such as an electron or nucleon being between two locations by examining its wave function or probability density;
31. Describe the principles of physics which are used to create Schrödinger's Equation;
32. Sketch the potential energy diagram from a physical situation;
33. Determine, from an energy diagram, the motion of a classical object,
34. Identify the classical turning points from an energy diagram
35. Sketch the wave function for an electron when you know the potential and total energies or when given a physical situation involving that electron,
36. Explain why a wave function must connect smoothly across a boundary;
37. Explain why a wave function must decrease in a region where the total energy is less than the potential energy,
38. Sketch the wave function for an electron entering a material when the total energy is either greater than or less than the potential energy;
39. Sketch possible wave functions for an electron when it enters a region where the potential energy changes;
40. Describe the logic that leads to the conclusion that quantum tunneling occurs,
41. Describe how the motion of a large object and a very small one will differ in regions where quantum tunneling occurs,
42. Explain why quantum tunneling is a surprising result when compared to classical physics,
43. Describe how the probability of quantum tunneling changes with variables such as the height of the potential energy, the total energy and the width of the potential energy;
44. Apply wave functions to explain why quantum tunneling occurs in real processes such as fusion and alpha radioactivity.
45. Explain why a wave packet must have many different wave functions included in it,
46. Explain how the wave nature of matter leads to the Uncertainty Principle,
47. Describe and use the relation between the uncertainty in position and uncertainty in momentum.
48. Describe how a wave packet changes over time,
49. Explain how the uncertainty in position changes as a function of our initial knowledge of a particle's location
50. Explain why the squared-off potential can be used to represent an atom and what its limitations are;
51. Be able to determine by looking at a potential energy diagram and a wave function if it is an acceptable wave function for a bound state;
52. Apply quantum mechanics to sketch acceptable solutions for an electron in a one-dimensional atom;
53. Explain how the wave nature of matter leads to the conclusion that discrete energies must exist in an atom;
54. Sketch a set of one-dimensional wave functions when given a spectrum of a gas;
55. Explain, using analogies such as a vibrating drum, why more than one wave function can exist with the same wave length in two or more dimensions
56. Describe how introducing more than one dimension for a representation of an atom leads to more than one state of the same energy;
57. Locate regions of high and low probability for finding an electron from representations of three-dimensional wave functions;
58. Explain why each energy state can contain only a limited number of electrons;
59. Explain how electron spin is important in determining the configuration of electrons in an atom;

60. Explain how "electron clouds" and orbitals are related to wave functions;
61. Apply the limitation on the number of electrons in each state to explain how quantum numbers and wave functions are related to the periodic table;
62. Explain how the presence of neutrons helps hold a nucleus together;
63. Describe the interactions among protons and neutrons in a nucleus;
64. Determine the products of a radioactive transformation by applying conservation laws,
65. Explain how the probabilistic nature of quantum mechanics leads to the concept of half-life;
66. Describe the products of alpha, beta and gamma radioactivity;
67. Explain the types of transformations when a neutron or proton is added to a stable nucleus,
68. Describe a radioactive “chain” of transformations and apply it to find a nucleus or emitted particle;
69. Determine the product of a beta transformation when either electrons or positrons are emitted;
70. Describe the process by which gamma radiation is emitted.
71. Build an energy level diagram of a nucleus from a gamma spectrum;
72. Explain how radioactive products interact with matter;
73. Apply the energy-mass relation to explain the basic process by which we obtain useful energy from nuclear transformations.
74. Describe fission and fusion.
75. Explain how energy can be released in both the fission and fusion processes.
76. Describe the basic process that converts energy from fission into electrical energy.
77. Explain why enrichment of uranium is needed to obtain fuel for nuclear reactors and weapons.
78. Describe why controlled fusion energy requires magnetic or similar containment.

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