CHAPTER 16. SOLIDS MATTER

Sections 16.5 through 16.11 contain somewhat more advanced material than the earlier sections of this chapter. Some classes may benefit from this material, while others may not. Instructors should decide how much, if any, of this material they wish to assign to their classes, or to individual students who may benefit from it.

Suggested Mini-Laboratory Explorations

- The Three States of Matter.

Suggested Major Laboratory Explorations

- Exploring Heat Transfer and the Latent Heat of Fusion.
- Investigating Electric Currents I.

Objectives

Most physicists today work in the field of condensed matter physics. The allied fields of electronics and materials science have undergone a revolution in recent years, affecting the lives of nearly everyone. Today's scientifically literate students need to possess some basic understanding of the quantum structure of matter and its applications which underlie current developments in these fields. After describing theories of conductivity and superconductivity and the rise of quantum band structure, the chapter discusses semiconductors, semiconductor devices, transistors, and some of their important uses.

Suggestions

The discussion of semiconductors, transistors, and their uses may become a little too abstract if students do not have access to hands-on activities with some of these devices. At the moment there are no inexpensive, readily available instructional models of these devices. Computer simulations may have to suffice until these become available.

The important topic of solid wastes could not be included in this chapter for reasons of space. We include a brief overview below for those students and instructors who might find it of interest and appropriate for the class.

Starting with section 16.5, the material involves more advanced concepts.

Some classes may benefit, while others may not. Some may want to study this on their own.

Further Reading

I. Amato, *Stuff: the Materials the World is Made Of* (New York: Avon, 1997).

P. Ball, *Made to Measure: New Materials for the 21st Century* (Princeton, NJ: Princeton University Press, 1997).

M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine* (New York: Basic Books, 1997).

G. Holton, H. Chang, and E. Jurkowitz, "How a Scientific Discovery Is Made: A Case History [high-temperature superconductivity]," *American Scientist*, **84** (1996), 364–375; also in G. Holton, *The Scientific Imagination* (Cambridge, MA: Harvard University Press, 1998).

R.E. Hummel, *Understanding Materials Science: History, Properties, Applications* (New York: Springer-Verlag, 1998).

N. Garcia et al., *Physics for Computer Science Students: With A New Emphasis on Atomic and Semiconductor Physics*, 2nd ed. (New York: Springer-Verlag, 1998).

H. Nowotny and U. Felt, *After the Breakthrough: The Emergence of High-Temperature Superconductivity* (New York: Cambridge University Press, 1997).

M.S. Pandit, *How Computers Really Work* (Berkeley, CA: Osborne McGraw-Hill, 1993).

M. Riordan and L. Hoddeson, *Crystal Fire: The Birth of the Information Age* (New York: Norton, 1997).

C.E. Swartz and T. Miner, *Teaching Introductory Physics: A Sourcebook* (Woodbury, NY: AIP Press, 1997), Chapter 21.

Web site

History of the transistor: http://www.pbs.org/transistor

CHAPTER 17. PROBING THE NUCLEUS

Suggested Mini-Laboratory Explorations

- Radioactivity and Half-Life.

Demonstrations

Demonstrate half-life through the example in the text of flipping coins. Have each student in the class flip a coin in order to demonstrate that each coin (by analogy: nucleus) acts independently of the others. Graph the results or perform other analyses to demonstrate the statistical yet predictable nature of half-life.

Since safety concerns usually prohibit students from directly experiencing radioactive sources, a demonstration by the instructor, using appropriate safety precautions, would be useful. This can involve the use of a Geiger counter to observe the attenuation of radioactive emissions as well as measuring background radiation.

Objectives

Continuing the detective metaphor, this chapter takes students on the exciting journey from radioactivity to the discovery of transmutation rules, reactions, and their applications. The chapter again demonstrates the close connection between empirical evidence and the construction of new concepts and theories. The statistical nature of radioactive decay echos the statistical features of quantum mechanics and of the kinetic theory of gases.

Suggestions

Many of the concepts, such as half-life, isotopes, and decay schemes, are new to most students. Nevertheless, many find this subject fascinating. Because of the potential safety problems in handling radioactive isotopes, we have had to resort to models and analogies in investigating nuclear properties. Students find this less than satisfactory, but still helpful if done with enthusiasm and imagination.

Further Reading

E. Curie, *Madame Curie: A Biography*, V. Sheean, transl. (New York: Da Capo Press, 1986).

G. Holton and S.C. Brush, *Physics, The Human Adventure* (Piscataway, NJ: Rutgers University Press, 2001), Chapter 27.

S. Quinn, *Marie Curie: A Life* (New York: Perseus Press, 1996).

Web site

"Marie Curie," http://www.aip.org/history/curie

CHAPTER 18. THE NUCLEUS AND ITS APPLICATIONS

Objectives

This chapter reiterates the theme that often the abstract developments in physics have profound practical consequences that can affect us all. Once again the aim is to inform students, as future decision makers and teachers, of some of the consequences of these developments and their current status.

Suggestions

Again, this chapter covers a great deal of territory—from the problem of nuclear structure to the controlled and uncontrolled release of nuclear energy. The scientific, social, and political consequences of these developments have been enormous. There is much material here for future informed citizens, including teachers, to consider and discuss among themselves.

Further Reading

L. Badash, *Scientists and the Development of Nuclear Weapons* (Amherst, NY: Prometheus Books, 1995).

R. Rhodes, *The Making of the Atomic Bomb* (New York: Touchstone Books, 1995)

R. Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Touchstone Books, 1996)

R. Sime, *Lise Meitner, A Life in Physics* (Chicago: University of Chicago Press, 1996).

E. Segrè, *Enrico Fermi Physicist* (Chicago: University of Chicago Press, 1995)

S. Weart, *Nuclear Fear: A History of Images* (Cambridge, MA: Harvard University Press, 1989).

Phys. Today, **50**, No. 6 (1997). Issue devoted to problem of nuclear waste.

G. Holton, Scientists organizing to fulfill their civic responsibility, *Physics and Society*, **28** (1999), 11–13.

J. Rothblat, *Scientists and the Quest for Peace: A History of the Pugwash Conferences* (Cambridge, MA: MIT Press, 1972).

Web site

"Andrei Sakharov: Soviet Physics, Nuclear Weapons, and Human Rights": http://www.aip.org/history/sakharov