UNIT IIID

THE PROPERTIES OF GASES COMPOSED OF LOW-MASS PARTICLES

Free Electrons and Electromagnetic and Acoustical Radiation

Determination of properties for gases composed of particles lighter than a proton require techniques that are different from those studied in Unit IIIC. This unit develops the methods required for the study of electromagnetic and acoustical waves, and free electrons. Since electromagnetic radiation is always present in a physical space it is a necessary part of any system. But its contribution to the properties of matter occupying the space is shown to be negligible. Properties of solids are developed by considering acoustic waves and free electrons.

Objectives.

At the conclusion of this unit the student should be able to:

1. Determine the energy, entropy, and particle density of a photon gas at a specified temperature.

2. Evaluate the phonon contribution to internal energy, specific heat, and entropy of an atomic lattice of specified Debye temperature.

3. Determine the Fermi temperature of a metallic solid.

4. Evaluate the free electron contribution to the internal energy or specific heat of a metallic solid.

5. Combine the phonon and free electron contributions to determine the total properties of an atomic lattice solid.

6. Describe the differences between the properties of an atomic and molecular lattice point crystal.

Supplementary References

1. Sonntag, R. E., and Van Wylen, G. J., Introduction to Thermodynamics: Classical and Statistical, Wiley (1971). Sect. 19.10 and Chapter 20, with Exers. 19.36 to 19.41, 20.1 to 20.7, 20.11, 20.13 to 20.18. Similar to this unit. A good supplement.

2. Holman, J. P., Thermodynamics, Second Ed., McGraw-Hill (1974). Sects. 8-7, 8-8 and 8-10 with Exmps. 8-3 to 8-7 and Exers. 8-2, 8-4, 8-7, 8-14, 8-18 to 8-23. Very brief treatment, though comprehensive and similar to this unit.

3. Wark, K., Thermodynamics, Second Ed., McGraw-Hill (1971). Sects. 10-17 to 10-19 with Exers. 10-38 to 10-45. Very brief.

4. Incropera, F. P., Molecular Structure and Thermodynamics, Wiley (1974). Sect. 13.3. Uses a different approach to radiation properties in Sect. 2.1, followed by an approach similar to that of this unit in Sect. 13.3. Chapter 12 and Sects. 13.1 and 13.2 complete the topics considered in this unit with examples and exercises. A good supplement.

5. Tien, C. L., and Lienhard, J. H., Statistical Thermodynamics, Holt, Rinehart, and Winston (1971). Chapter 6 develops the statistics of degenerate particles using a different approach from the unit. Photons and free electrons are discussed. The