

Homework

Problems 3.5, 3.7, 3.14, 3.20, 3.21, 3.23, 3.31, 3.32, 3.37

Chapter 3

Problem 3.5. Starting with the result of Problem 2.17, find a formula for the temperature of an Einstein solid in the limit $q \ll N$. Solve for the energy as a function of temperature to obtain $U = N\epsilon e^{-\frac{U}{N\epsilon}}$ (where ϵ is the size of an energy unit).

The definition of temperature in terms of energy is

$$\frac{1}{T} = \frac{\partial S}{\partial U}$$

Let's look at the Einstein solid in low temperature case where the number of energy quanta (q) is very small than the number of oscillations (N). (i.e. $q \ll N$) The multiplicity of such a system is approximately

$$\Omega \approx \left(\frac{N+q}{q} \right)^q$$

The total energy of the system is $U = q\epsilon$ so

$$\Omega \approx \left(\frac{N+\epsilon q}{U} \right)^q$$

Hence the entropy is

$$S = k \ln \Omega$$

$$= k \ln \left(\frac{N+\epsilon q}{U} \right)^q = k q \ln \left(\frac{N+\epsilon q}{U} \right)$$

$$= k q \cdot \{ \ln(N+\epsilon q) - \ln(U) \}$$

$$= \frac{k U}{\epsilon} (\ln(\epsilon N) + 1 - \ln(U))$$

So,

$$\frac{\partial S}{\partial U} = k \frac{\partial (\ln \Omega)}{\partial U}$$

$$\frac{1}{T} = \frac{k}{\epsilon} \frac{\partial U (\ln(\epsilon N) + 1 - \ln(U))}{\partial U}$$

(Using Product Rule)

$$= \frac{k}{\epsilon} (\ln(\epsilon N) + 1 - \ln(U)) - \frac{k}{\epsilon}$$

$$= \frac{k}{\epsilon} (\ln(\epsilon N) - \ln(U))$$

Schroeder Thermal Physics Solutions Chapter 3

R Barnett



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An Introduction to Thermal Physics Daniel V. Schroeder, 2021 This is a textbook for the standard undergraduate level course in thermal physics sometimes called thermodynamics or statistical mechanics Originally published in 1999 it quickly gained market share and has now been the most widely used English language text for such courses as taught in physics departments for more than a decade Its clear and accessible writing style has also made it popular among graduate students and professionals who want to gain a better understanding of thermal physics The book explores applications to engineering chemistry biology geology atmospheric science astrophysics cosmology and everyday life It includes two appendices

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Table of Contents Schroeder Thermal Physics Solutions Chapter 3

1. Understanding the eBook Schroeder Thermal Physics Solutions Chapter 3
 - The Rise of Digital Reading Schroeder Thermal Physics Solutions Chapter 3
 - Advantages of eBooks Over Traditional Books
2. Identifying Schroeder Thermal Physics Solutions Chapter 3
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Schroeder Thermal Physics Solutions Chapter 3
 - User-Friendly Interface
4. Exploring eBook Recommendations from Schroeder Thermal Physics Solutions Chapter 3
 - Personalized Recommendations
 - Schroeder Thermal Physics Solutions Chapter 3 User Reviews and Ratings
 - Schroeder Thermal Physics Solutions Chapter 3 and Bestseller Lists
5. Accessing Schroeder Thermal Physics Solutions Chapter 3 Free and Paid eBooks
 - Schroeder Thermal Physics Solutions Chapter 3 Public Domain eBooks
 - Schroeder Thermal Physics Solutions Chapter 3 eBook Subscription Services

- Schroeder Thermal Physics Solutions Chapter 3 Budget-Friendly Options
- 6. Navigating Schroeder Thermal Physics Solutions Chapter 3 eBook Formats
 - ePub, PDF, MOBI, and More
 - Schroeder Thermal Physics Solutions Chapter 3 Compatibility with Devices
 - Schroeder Thermal Physics Solutions Chapter 3 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Schroeder Thermal Physics Solutions Chapter 3
 - Highlighting and Note-Taking Schroeder Thermal Physics Solutions Chapter 3
 - Interactive Elements Schroeder Thermal Physics Solutions Chapter 3
- 8. Staying Engaged with Schroeder Thermal Physics Solutions Chapter 3
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Schroeder Thermal Physics Solutions Chapter 3
- 9. Balancing eBooks and Physical Books Schroeder Thermal Physics Solutions Chapter 3
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Schroeder Thermal Physics Solutions Chapter 3
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Schroeder Thermal Physics Solutions Chapter 3
 - Setting Reading Goals Schroeder Thermal Physics Solutions Chapter 3
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Schroeder Thermal Physics Solutions Chapter 3
 - Fact-Checking eBook Content of Schroeder Thermal Physics Solutions Chapter 3
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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