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Chapter 5: Atom and Ion Movements in Materials

5-10 Atoms are found to move from one lattice position to another at the rate of 5 × 10³ jumps/s at 400°C when the activation energy for their movement is 30,000 cal/mol. Calculate the jump rate at 750°C.

Solution:

Rate =
$$\frac{5 \times 10^3}{x} = \frac{c \exp[-30,000/(1.987)/(673)]}{c \exp[-30,000/(1.987)/(1023)]} = \exp(-22.434 + 14.759)$$

 $\frac{5 \times 10^3}{x} = \exp(-7.675) = 4.64 \times 10^{-4}$
 $x = \frac{5 \times 10^3}{4.64 \times 10^{-4}} = 1.08 \times 10^9 \text{ jumps/s}$

5-11 The number of vacancies in a material is related to temperature by an Arrhenius equation. If the fraction of lattice points containing vacancies is 8 × 10⁻⁶ at 600°C, determine the fraction of lattice points containing vacancies at 1000°C.

Solution:
$$8 \times 10^{-5} = \exp[-Q/(1.987)/(873)]$$
 $Q = 16,364 \text{ cal/mol}$ $f = n_n/n = \exp[-16,364/(1.987)/(1273)] = 0.00155$

5-12 The Arrhenius equation was originally developed for comparing rates of chemical reactions. Compare the rates of a chemical reaction at 20 and 100°C by calculating the ratio of the chemical reaction rates. Assume that the activation energy for liquids in which the chemical reaction is conducted is 10 kJ/mol and that the reaction is limited by diffusion.

Solution:

An Arrhenius relationship gives the rate of a process or reaction as a function of temperature. In general, for an Arrhenius relationship,

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G Orfield



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Table of Contents Askeland Solutions Manual

- 1. Understanding the eBook Askeland Solutions Manual
 - The Rise of Digital Reading Askeland Solutions Manual
 - Advantages of eBooks Over Traditional Books
- 2. Identifying Askeland Solutions Manual
 - 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 Askeland Solutions Manual
 - User-Friendly Interface
- 4. Exploring eBook Recommendations from Askeland Solutions Manual
 - Personalized Recommendations
 - Askeland Solutions Manual User Reviews and Ratings
 - Askeland Solutions Manual and Bestseller Lists
- 5. Accessing Askeland Solutions Manual Free and Paid eBooks
 - Askeland Solutions Manual Public Domain eBooks
 - Askeland Solutions Manual eBook Subscription Services
 - Askeland Solutions Manual Budget-Friendly Options

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

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