

DIRECT FORMULA FOR \bar{E} in H.O

$\bar{E} = \frac{1}{2} kT$ for each term (K & D P.E)

c.g. In 3-D, 3 K.E & 3 P.E terms

$\bar{E} = kT + kT + kT = 3kT$

$\bar{E} = 3kT$

but if particles are non interacting

$\Rightarrow \bar{E} = \frac{1}{2} kT + \frac{1}{2} kT + \frac{1}{2} kT$

$\Rightarrow \bar{E} = \frac{3}{2} kT$

For H.O.

$Z = \sum_{n=0}^{\infty} e^{-\beta (n + \frac{1}{2}) h\nu}$

$Z = e^{-h\nu\beta/2} + e^{-3h\nu\beta/2} + \dots$

GP series

$a = e^{-h\nu\beta/2} \quad r = e^{-\beta h\nu}$

$\therefore Z = \frac{e^{-\beta h\nu/2}}{1 - e^{-\beta h\nu}}$

For 3D HO, $Z_N = \left(\frac{1}{1 - e^{-\beta h\nu}}\right)^3 N$

Average value of $n = \frac{1}{2}$ (classical)

Partition fn for particles in magnetic field

$Z = e^{-\beta E} = e^{-\beta(\vec{\mu} \cdot \vec{H})} = e^{-\beta(\vec{\mu} \cdot \vec{B})}$

up $\rightarrow \mu B$, down $\rightarrow -\mu B$

$Z = e^{-\mu\beta B} + e^{\mu\beta B}$

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EXAMPLE \rightarrow If $F = NkT \ln\left(\frac{2\omega V}{N} (kT)^{5/2}\right)$

Find U.

Soln. As $F = -NkT \ln Z$

$\Rightarrow Z = \frac{2\omega V (kT)^{5/2}}{N}$

$U = -\frac{\partial}{\partial \beta} (\ln Z) = -\frac{\partial}{\partial \beta} \left(\ln\left(\frac{2\omega V}{N} (kT)^{5/2}\right) \right)$

$= \frac{5N}{2\beta} = \frac{5}{2} NkT$

$U = \frac{5}{2} NkT$

Ensemble \rightarrow system of collection of similar systems having some const parameters

Microcanonical

Walls are rigid impermeable well insulated

N, V, E

Microcanonical

Canonical

Walls are rigid conducting impenetrable

V, N, T

Canonical

Grand canonical

Walls are impenetrable rigid conducting

μ, V, T

Grand canonical

These quantities remain same in a particle ensemble i.e. in microcanonical, canonical & Grand canonical resp. $\frac{1}{kT} \leftarrow$ Energy fluctuation $\rightarrow \frac{1}{N}$

Maxwell Boltzmann distⁿ law of velocities

No. of particles in velocity range v to $v+dv$ is

$n(v_x) dv_x = N \left(\frac{m}{2\pi kT}\right)^{1/2} e^{-\frac{mv_x^2}{2kT}} dv_x$

$P = \frac{n}{N} = \left(\frac{m}{2\pi kT}\right)^{1/2} e^{-\frac{mv_x^2}{2kT}}$

$P_{max} = \left(\frac{m}{2\pi kT}\right)^{1/2} \left(\frac{kT}{m}\right)^{1/2}$

$\bar{v}_x = \int_{-\infty}^{\infty} v_x P dv_x = 0$

$\bar{v}_x = \bar{v}_y = \bar{v}_z = 0$

$\langle v_x v_y \rangle = \langle v_y v_x \rangle = \langle v_z v_x \rangle = 0$

In 1-D $\langle v_x^2 \rangle = \langle v_y^2 \rangle = \langle v_z^2 \rangle = kT/m$

In 2-D $\langle v_x^2 \rangle = \langle v_y^2 \rangle = \langle v_z^2 \rangle = 2kT/m$

In 3-D $\langle v_x^2 \rangle = \langle v_y^2 \rangle = \langle v_z^2 \rangle = 3kT/m$

Statistical Physics

Puja Mehta



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Table of Contents Statistical Physics

1. Understanding the eBook Statistical Physics
 - The Rise of Digital Reading Statistical Physics
 - Advantages of eBooks Over Traditional Books
2. Identifying Statistical Physics
 - 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 Statistical Physics
 - User-Friendly Interface
4. Exploring eBook Recommendations from Statistical Physics
 - Personalized Recommendations

- Statistical Physics User Reviews and Ratings
- Statistical Physics and Bestseller Lists
- 5. Accessing Statistical Physics Free and Paid eBooks
 - Statistical Physics Public Domain eBooks
 - Statistical Physics eBook Subscription Services
 - Statistical Physics Budget-Friendly Options
- 6. Navigating Statistical Physics eBook Formats
 - ePub, PDF, MOBI, and More
 - Statistical Physics Compatibility with Devices
 - Statistical Physics Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Statistical Physics
 - Highlighting and Note-Taking Statistical Physics
 - Interactive Elements Statistical Physics
- 8. Staying Engaged with Statistical Physics
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Statistical Physics
- 9. Balancing eBooks and Physical Books Statistical Physics
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Statistical Physics
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Statistical Physics
 - Setting Reading Goals Statistical Physics
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Statistical Physics
 - Fact-Checking eBook Content of Statistical Physics

- 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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