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## Unit 9 - Week 7

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### Course outline

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Two Level System (Canonical Ensemble)

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### Assignment 7

The due date for submitting this assignment has passed. As per our records you have not submitted this assignment.

Due on 2019-03-20, 23:59 IST

1) In thermal equilibrium  $\beta = (k_B T)^{-1}$ , the expression below represents 1 point

$$\frac{\sum_i E_i e^{-\beta E_i}}{\sum_i e^{-\beta E_i}}$$

- average energy of the system.
- partition function of the system.
- probability to find the system in the state  $E_i$ .
- a constant of the order unity.

No, the answer is incorrect.

Score: 0

Accepted Answers:

average energy of the system.

2) 1 point

In the canonical ensemble, the ratio of standard deviation  $\sqrt{\langle \mathcal{H}^2 \rangle_c}$  to the mean of inter energy  $\langle \mathcal{H} \rangle$  scales as

- $N^0$ .
- $N^{1/2}$ .
- $N^{-1/2}$ .
- $N$ .

No, the answer is incorrect.

Score: 0

Accepted Answers:

$N^{-1/2}$ .

3) 1 point

The Hamiltonian of  $N$  classical harmonic oscillators in 3 dimensions is given as -

$$\mathcal{H}(\{\vec{q}_i, \vec{p}_i\}) = \sum_{i=1}^N \frac{p_i^2}{2m} + \frac{1}{2} m \omega^2 q_i^2$$

If the system is maintained at constant temperature, the canonical partition function becom

- $\mathcal{Z}(N, V, T) = (\beta \hbar \omega)^{-3N}$ .

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Accepted Answers:

$$\mathcal{Z}(N, V, T) = (\beta \hbar \omega)^{-3N}.$$

4)

1 point

The Hamiltonian of  $N$  independent quantum oscillators in 1 dimension is given as -

$$\mathcal{H}(\{n_i\}) = \sum_{i=1}^N \left( n_i + \frac{1}{2} \right) \hbar \omega, \quad \text{excitation } n_i = 0, 1, 2, \dots$$

If the system is maintained at constant temperature  $T$ , the average energy is given by

- $\langle \mathcal{H} \rangle = \hbar \omega / 2.$
- $\langle \mathcal{H} \rangle = N \hbar \omega \left[ \frac{1}{2} + \frac{1}{e^{\beta \hbar \omega} - 1} \right].$
- $\langle \mathcal{H} \rangle = 0.$
- $\langle \mathcal{H} \rangle = N \hbar \omega \left[ \frac{1}{2} + \frac{1}{e^{-\beta \hbar \omega} - 1} \right].$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\langle \mathcal{H} \rangle = N \hbar \omega \left[ \frac{1}{2} + \frac{1}{e^{\beta \hbar \omega} - 1} \right].$$

5)

1 point

Particles of radius  $a$  and mass  $m$  are dispersed in water at temperature  $T$ . Take gravity acting downwards and the joint probability of finding particles with position  $\vec{r}$  and moment  $\vec{p} = m\vec{v}$  as

$$\mathcal{P}(\vec{r}, \vec{v}) = \frac{e^{-\beta \mathcal{H}(\vec{r}, \vec{v})}}{\int \int e^{-\beta \mathcal{H}(\vec{r}, \vec{v})} d^3 \vec{r} d^3 \vec{v}} \quad \text{with } \mathcal{H} = mv^2/2 + mgz$$

The distribution of molecules as a function of depth  $z$  is thus given by

- $\mathcal{P}(z) = \beta mg e^{-\beta mgz}.$
- $\mathcal{P}(z) = (1/z) e^{-\beta mgz}.$
- $\mathcal{P}(z) = (1/z).$
- $\mathcal{P}(z) = (1/z) e^{-(\beta mgz)^2}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\mathcal{P}(z) = \beta mg e^{-\beta mgz}.$$

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