PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Canonical Ensemble - CSIR NET Physics PYQs

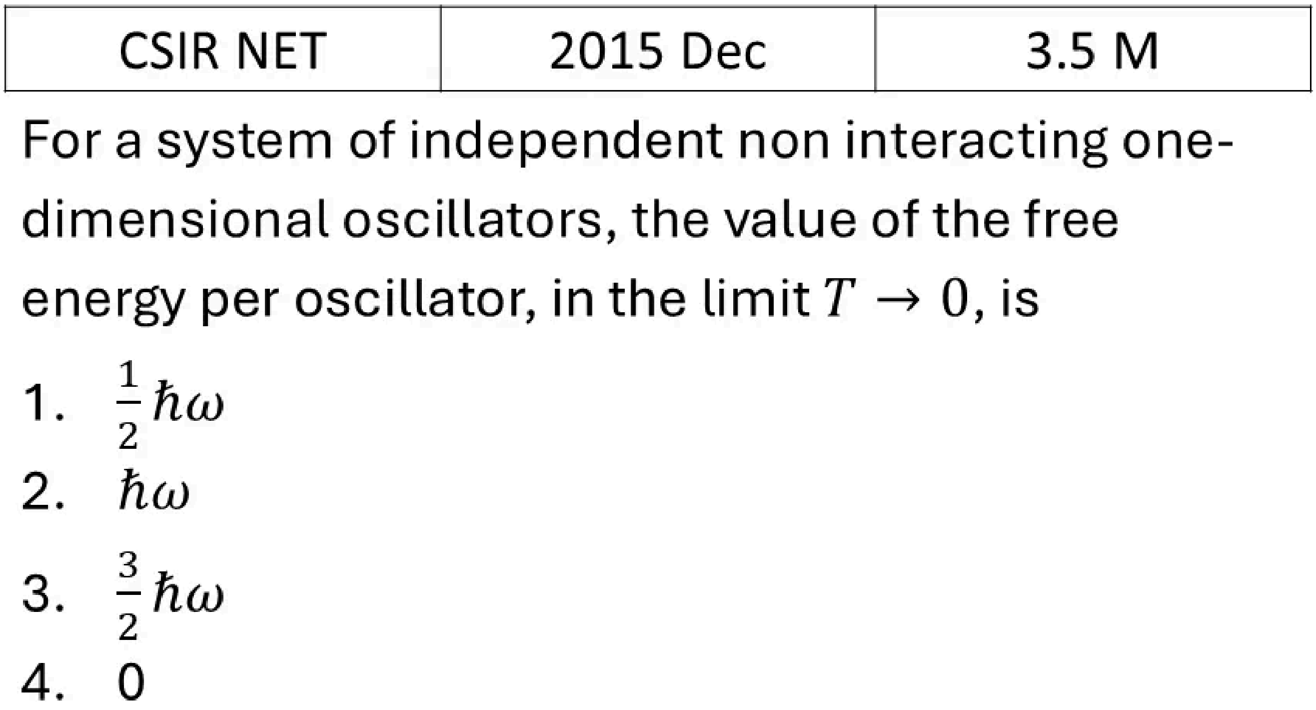
Statistical Mechanics . All PYQs (2015-2025) with answer key

36 questions . Answer key included

www.physicsbyaaryan.com . www.csirnetphysics.com
Contact: 9501976811

Q1. [Dec 2015] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



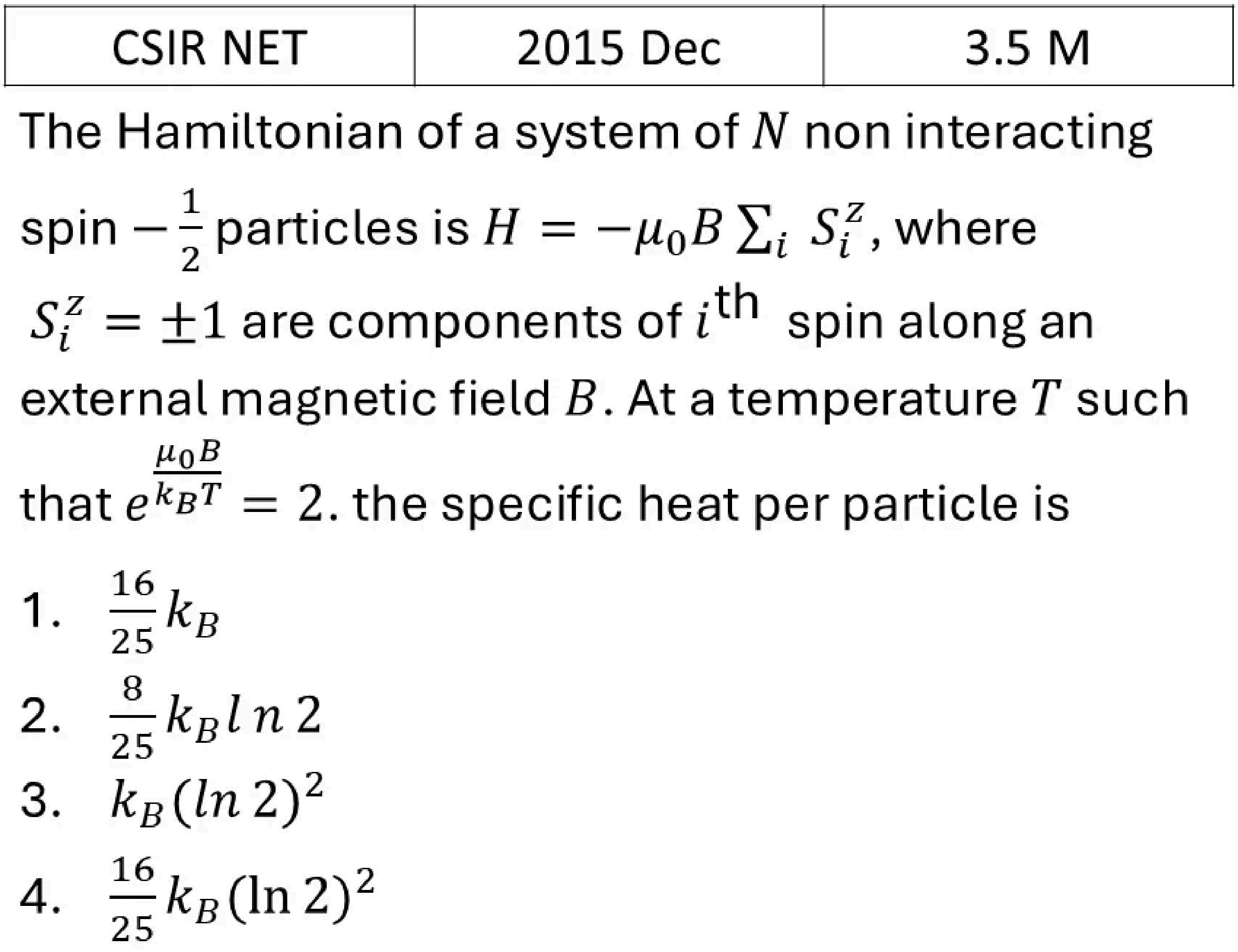
CSIR NET	2015 Dec	3.5 M

For a system of independent non interacting one-dimensional oscillators, the value of the free energy per oscillator, in the limit $T \to 0$, is

1. $\frac{1}{2}\hbar\omega$
2. $\hbar\omega$
3. $\frac{3}{2}\hbar\omega$
4. 0

Q2. [Dec 2015] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



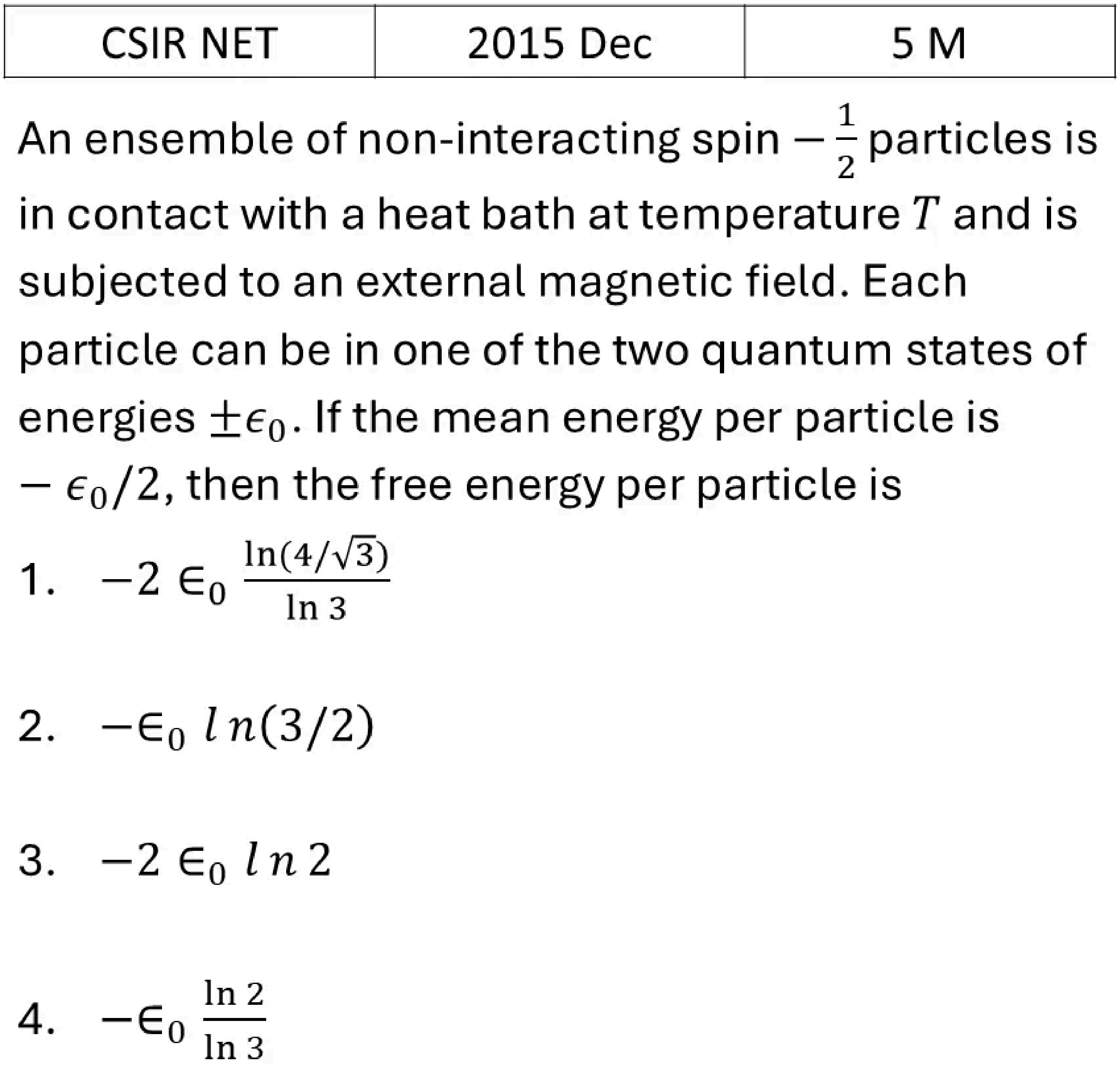
CSIR NET	2015 Dec	3.5 M

The Hamiltonian of a system of N non interacting spin $-\frac{1}{2}$ particles is $H = -\mu_0 B \sum_i S_i^z$, where $S_i^z = \pm 1$ are components of i^{th} spin along an external magnetic field B. At a temperature T such that $e^{\frac{\mu_0 B}{k_B T}} = 2$. the specific heat per particle is

1. $\frac{16}{25} k_B$
2. $\frac{8}{25} k_B \, l\, n\, 2$
3. $k_B (ln\, 2)^2$
4. $\frac{16}{25} k_B (\ln 2)^2$

Q3. [Dec 2015] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2015 Dec	5 M

An ensemble of non-interacting spin $-\frac{1}{2}$ particles is in contact with a heat bath at temperature T and is subjected to an external magnetic field. Each particle can be in one of the two quantum states of energies $\pm\epsilon_0$. If the mean energy per particle is $-\epsilon_0/2$, then the free energy per particle is

1. $-2 \in_0 \frac{\ln(4/\sqrt{3})}{\ln 3}$

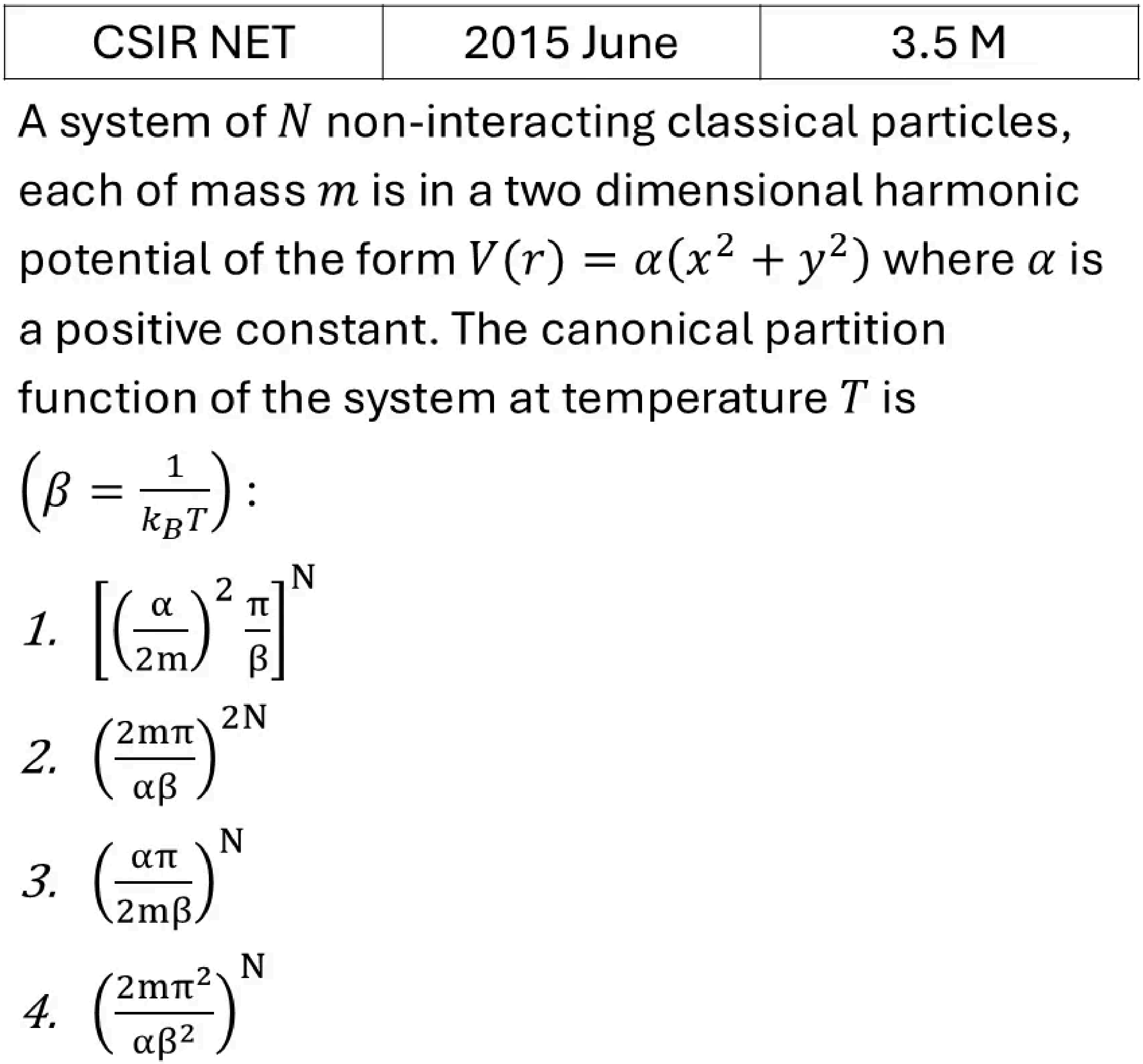
2. $-\in_0 ln(3/2)$

3. $-2 \in_0 ln\, 2$

4. $-\in_0 \frac{\ln 2}{\ln 3}$

Q4. [June 2015] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



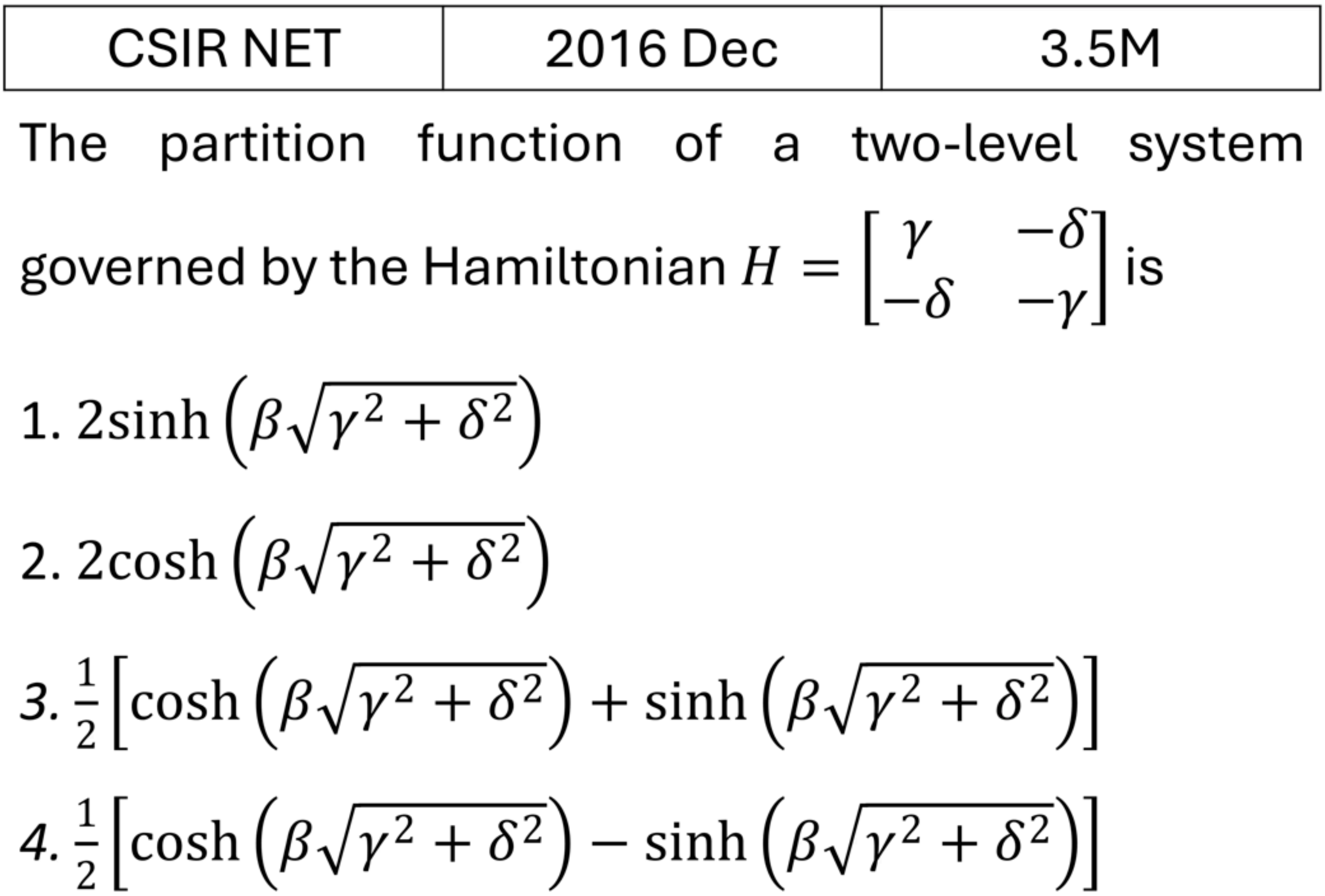
CSIR NET	2015 June	3.5 M

A system of N non-interacting classical particles, each of mass m is in a two dimensional harmonic potential of the form $V(r) = \alpha(x^2 + y^2)$ where α is a positive constant. The canonical partition function of the system at temperature T is $\left(\beta = \frac{1}{k_B T}\right)$:

1. $\left[\left(\frac{\alpha}{2m}\right)^2 \frac{\pi}{\beta}\right]^N$
2. $\left(\frac{2m\pi}{\alpha\beta}\right)^{2N}$
3. $\left(\frac{\alpha\pi}{2m\beta}\right)^N$
4. $\left(\frac{2m\pi^2}{\alpha\beta^2}\right)^N$

Q5. [Dec 2016] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



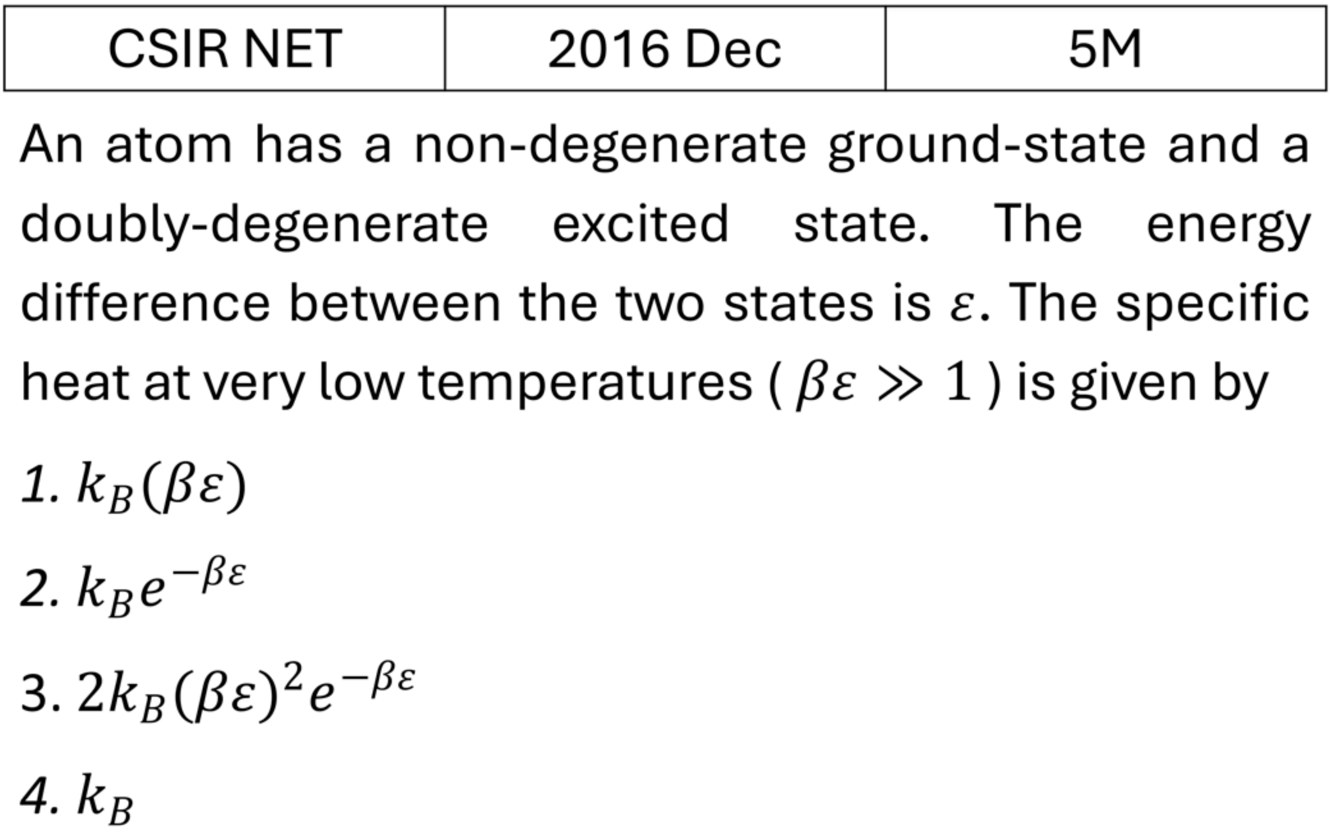
CSIR NET	2016 Dec	3.5M

The partition function of a two-level system governed by the Hamiltonian $H = \begin{bmatrix} \gamma & -\delta \\ -\delta & -\gamma \end{bmatrix}$ is

1. $2\sinh\left(\beta\sqrt{\gamma^2+\delta^2}\right)$
2. $2\cosh\left(\beta\sqrt{\gamma^2+\delta^2}\right)$
3. $\frac{1}{2}\left[\cosh\left(\beta\sqrt{\gamma^2+\delta^2}\right)+\sinh\left(\beta\sqrt{\gamma^2+\delta^2}\right)\right]$
4. $\frac{1}{2}\left[\cosh\left(\beta\sqrt{\gamma^2+\delta^2}\right)-\sinh\left(\beta\sqrt{\gamma^2+\delta^2}\right)\right]$

Q6. [Dec 2016] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



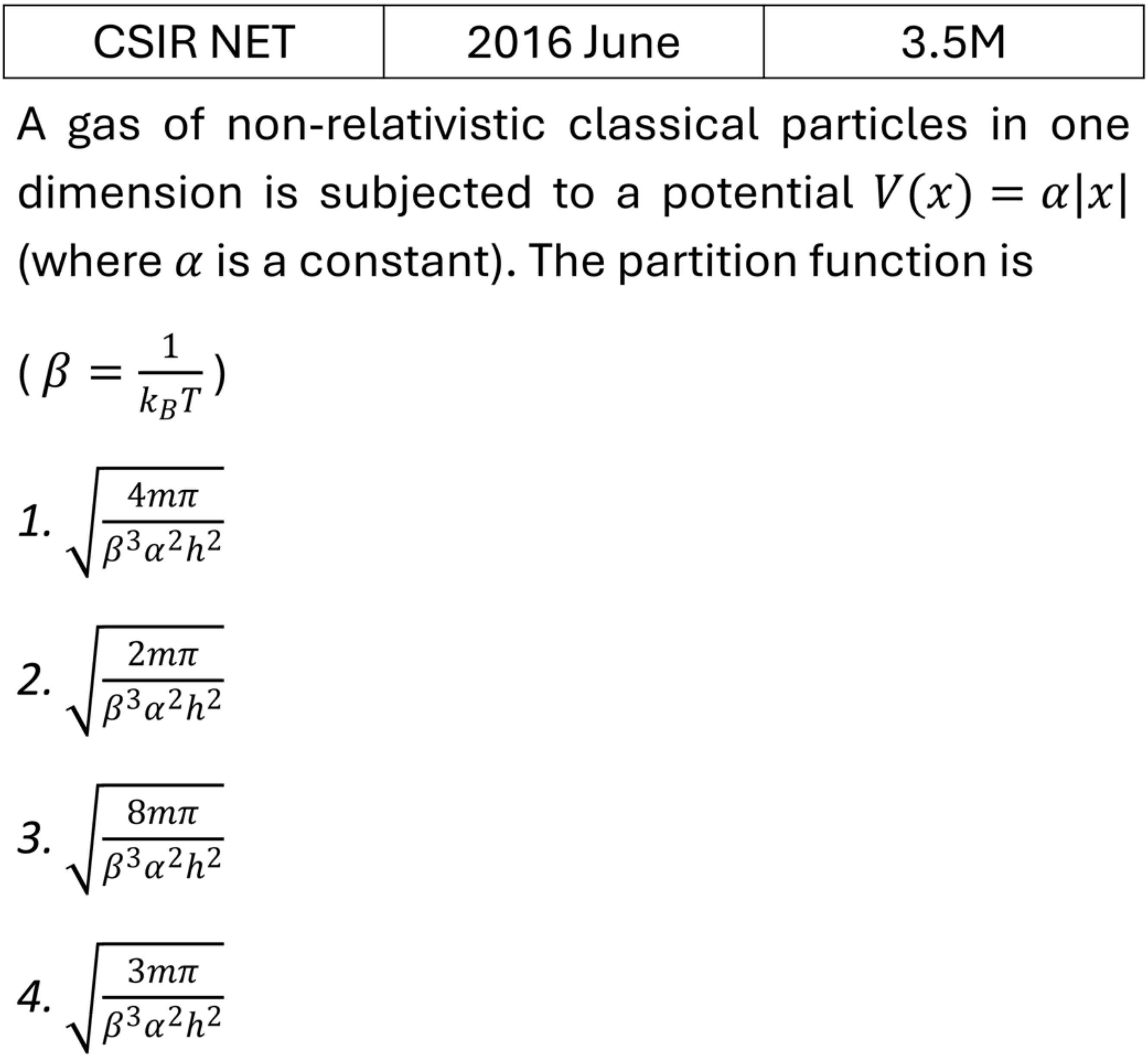
CSIR NET	2016 Dec	5M

An atom has a non-degenerate ground-state and a doubly-degenerate excited state. The energy difference between the two states is ε. The specific heat at very low temperatures ($\beta\varepsilon \gg 1$) is given by

1. $k_B(\beta\varepsilon)$
2. $k_B e^{-\beta\varepsilon}$
3. $2k_B(\beta\varepsilon)^2 e^{-\beta\varepsilon}$
4. k_B

Q7. [June 2016] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2016 June	3.5M

A gas of non-relativistic classical particles in one dimension is subjected to a potential $V(x) = \alpha|x|$ (where α is a constant). The partition function is

$(\beta = \frac{1}{k_B T})$

1. $\sqrt{\frac{4m\pi}{\beta^3\alpha^2h^2}}$

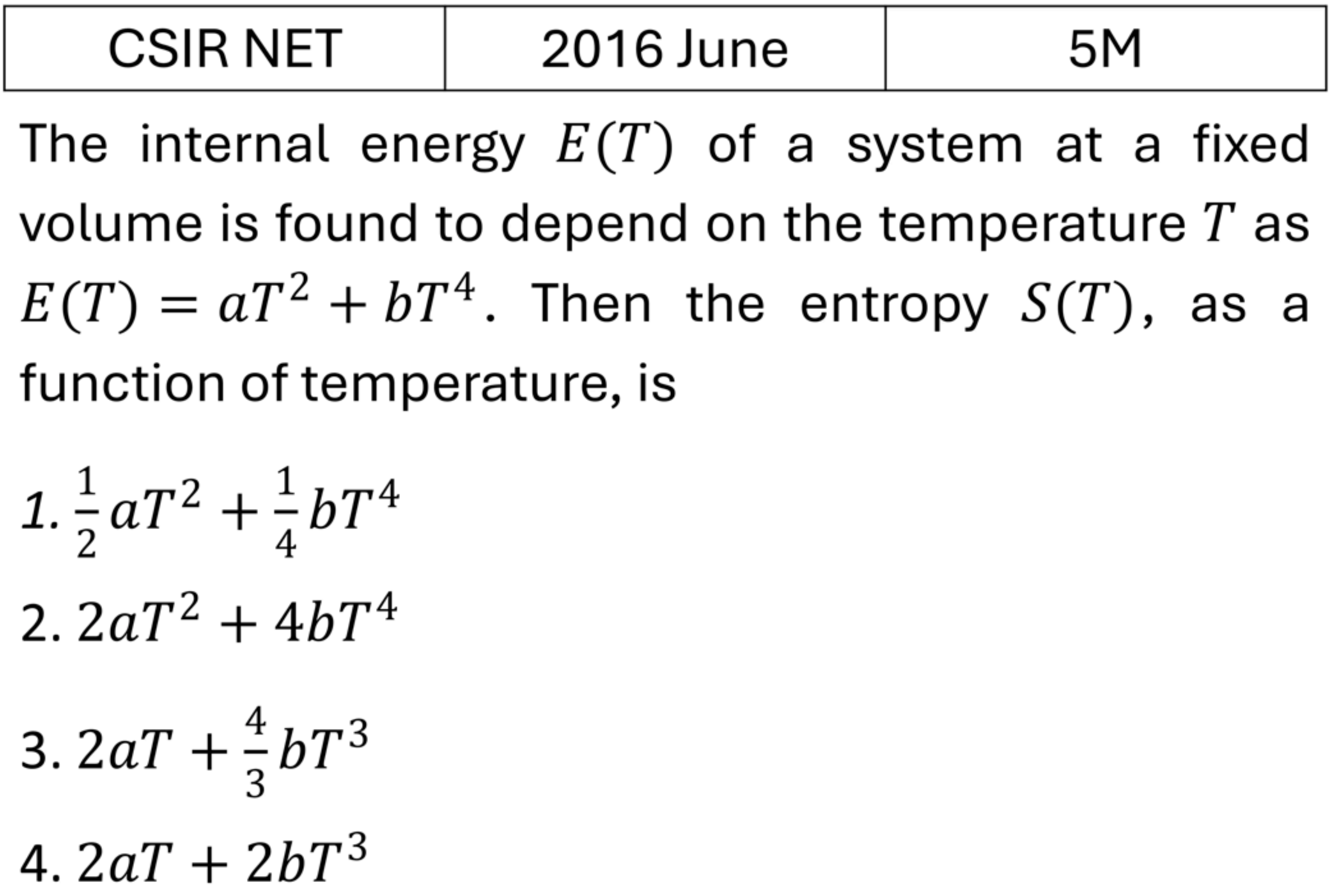
2. $\sqrt{\frac{2m\pi}{\beta^3\alpha^2h^2}}$

3. $\sqrt{\frac{8m\pi}{\beta^3\alpha^2h^2}}$

4. $\sqrt{\frac{3m\pi}{\beta^3\alpha^2h^2}}$

Q8. [June 2016] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



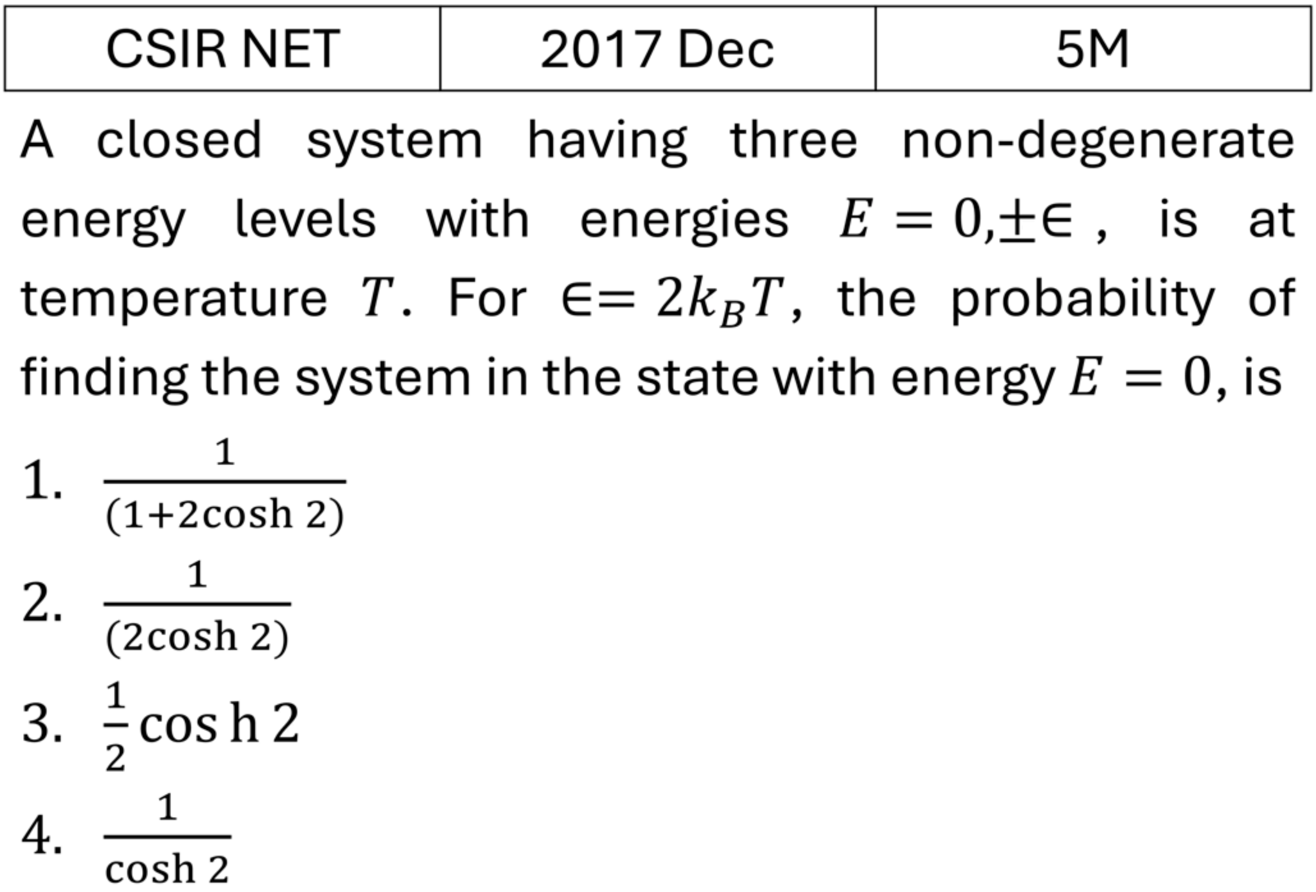
CSIR NET	2016 June	5M

The internal energy $E(T)$ of a system at a fixed volume is found to depend on the temperature T as $E(T) = aT^2 + bT^4$. Then the entropy $S(T)$, as a function of temperature, is

1. $\frac{1}{2}aT^2 + \frac{1}{4}bT^4$
2. $2aT^2 + 4bT^4$
3. $2aT + \frac{4}{3}bT^3$
4. $2aT + 2bT^3$

Q9. [Dec 2017] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



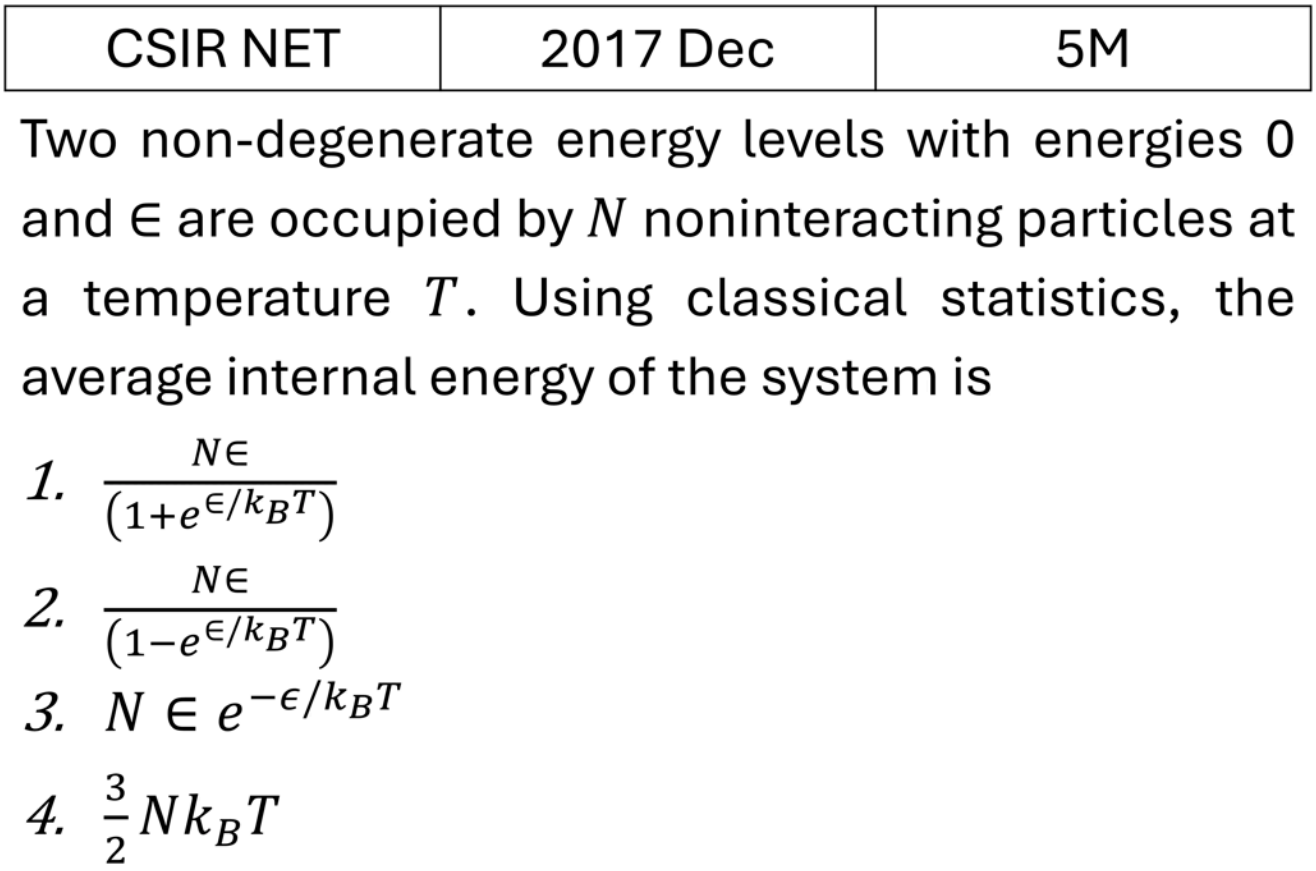
CSIR NET	2017 Dec	5M

A closed system having three non-degenerate energy levels with energies $E = 0, \pm \in$, is at temperature T. For $\in = 2k_B T$, the probability of finding the system in the state with energy $E = 0$, is

1. $\frac{1}{(1+2\cosh 2)}$
2. $\frac{1}{(2\cosh 2)}$
3. $\frac{1}{2}\cos h\, 2$
4. $\frac{1}{\cosh 2}$

Q10. [Dec 2017] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



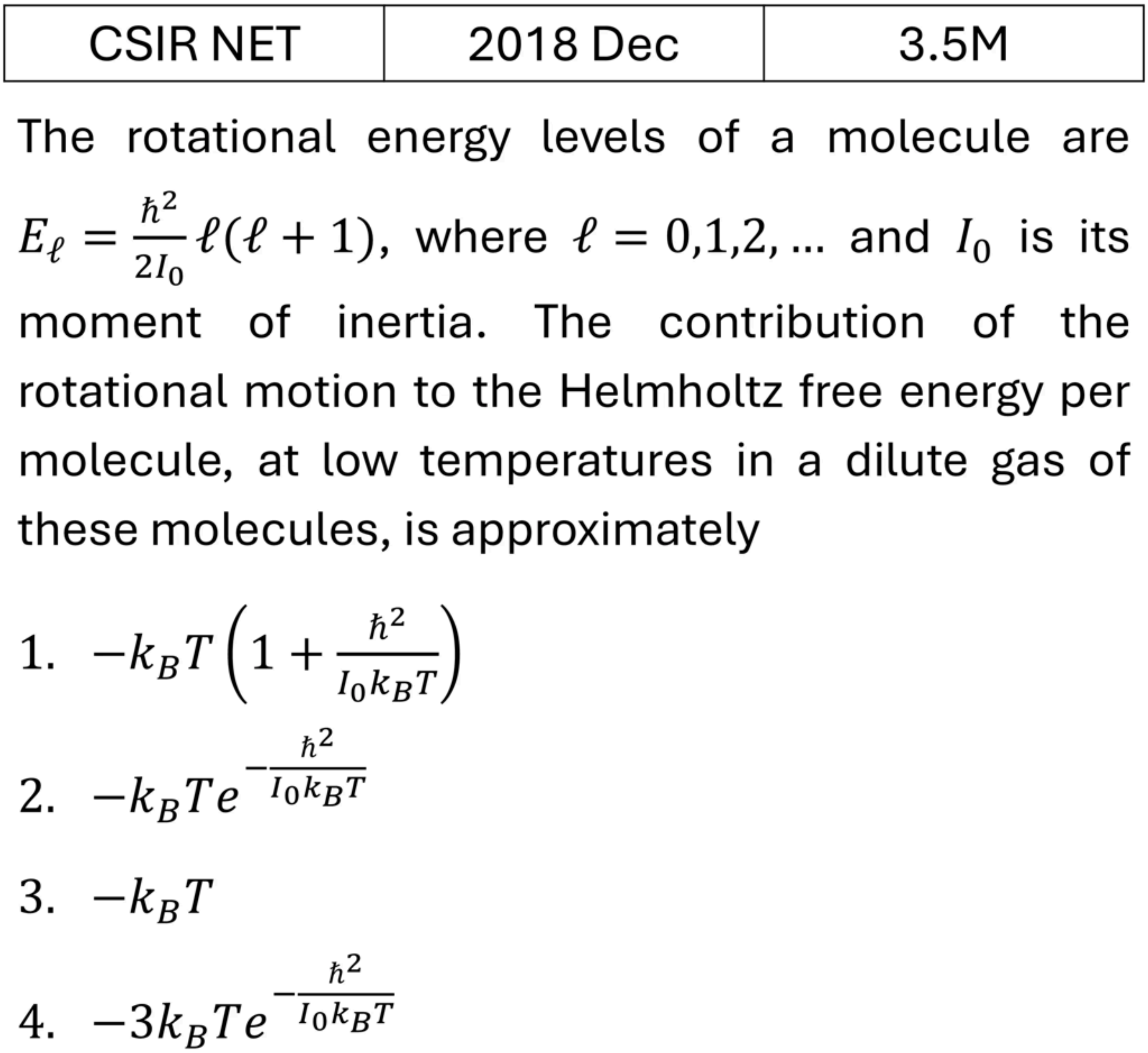
CSIR NET	2017 Dec	5M

Two non-degenerate energy levels with energies 0 and ∈ are occupied by N noninteracting particles at a temperature T. Using classical statistics, the average internal energy of the system is

1. $\frac{N\in}{\left(1+e^{\in/k_BT}\right)}$
2. $\frac{N\in}{\left(1-e^{\in/k_BT}\right)}$
3. $N \in e^{-\epsilon/k_BT}$
4. $\frac{3}{2}Nk_BT$

Q11. [Dec 2018] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



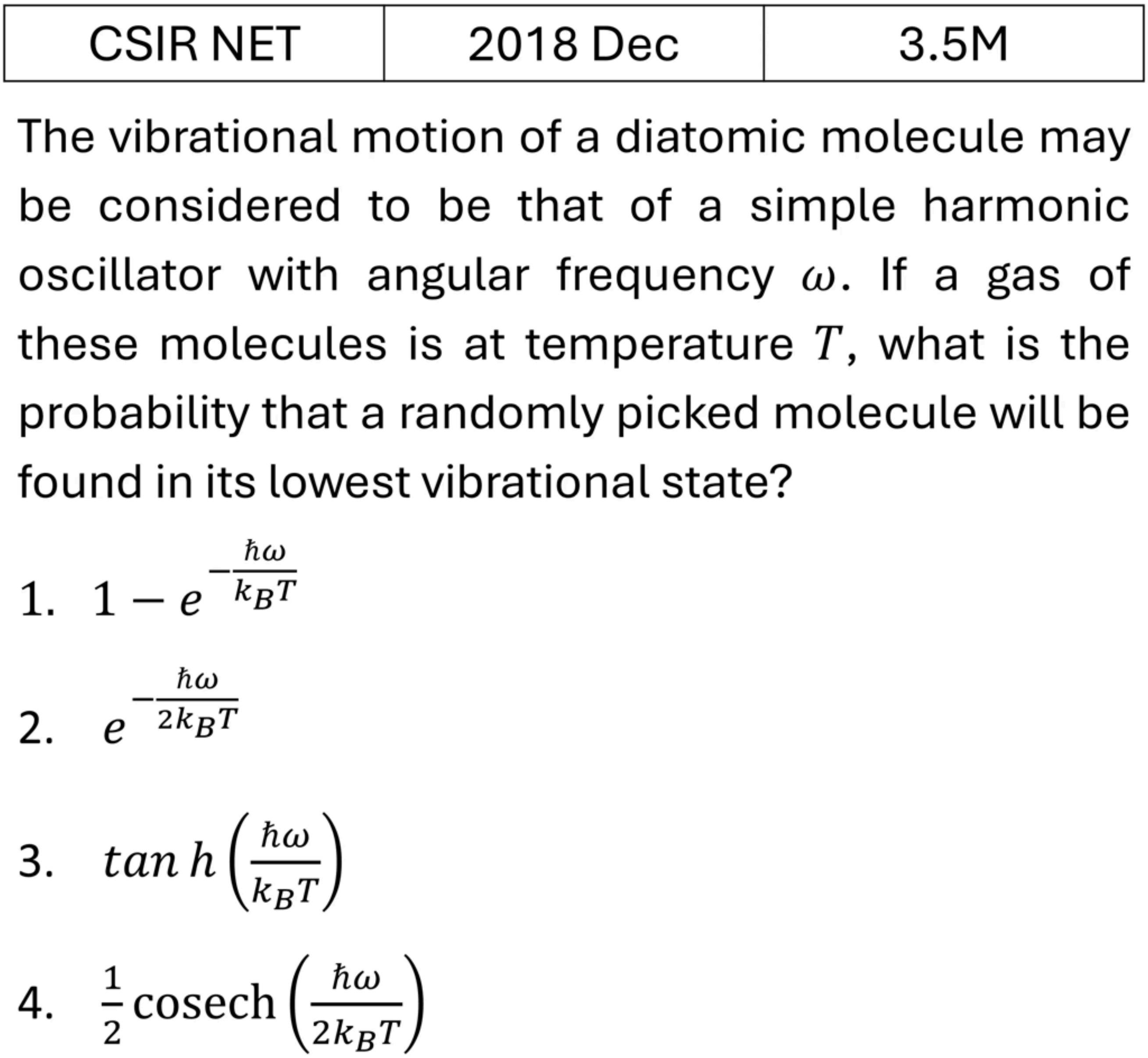
CSIR NET	2018 Dec	3.5M

The rotational energy levels of a molecule are $E_\ell = \frac{\hbar^2}{2I_0}\ell(\ell+1)$, where $\ell = 0,1,2,\ldots$ and I_0 is its moment of inertia. The contribution of the rotational motion to the Helmholtz free energy per molecule, at low temperatures in a dilute gas of these molecules, is approximately

1. $-k_BT\left(1+\frac{\hbar^2}{I_0k_BT}\right)$
2. $-k_BTe^{-\frac{\hbar^2}{I_0k_BT}}$
3. $-k_BT$
4. $-3k_BTe^{-\frac{\hbar^2}{I_0k_BT}}$

Q12. [Dec 2018] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



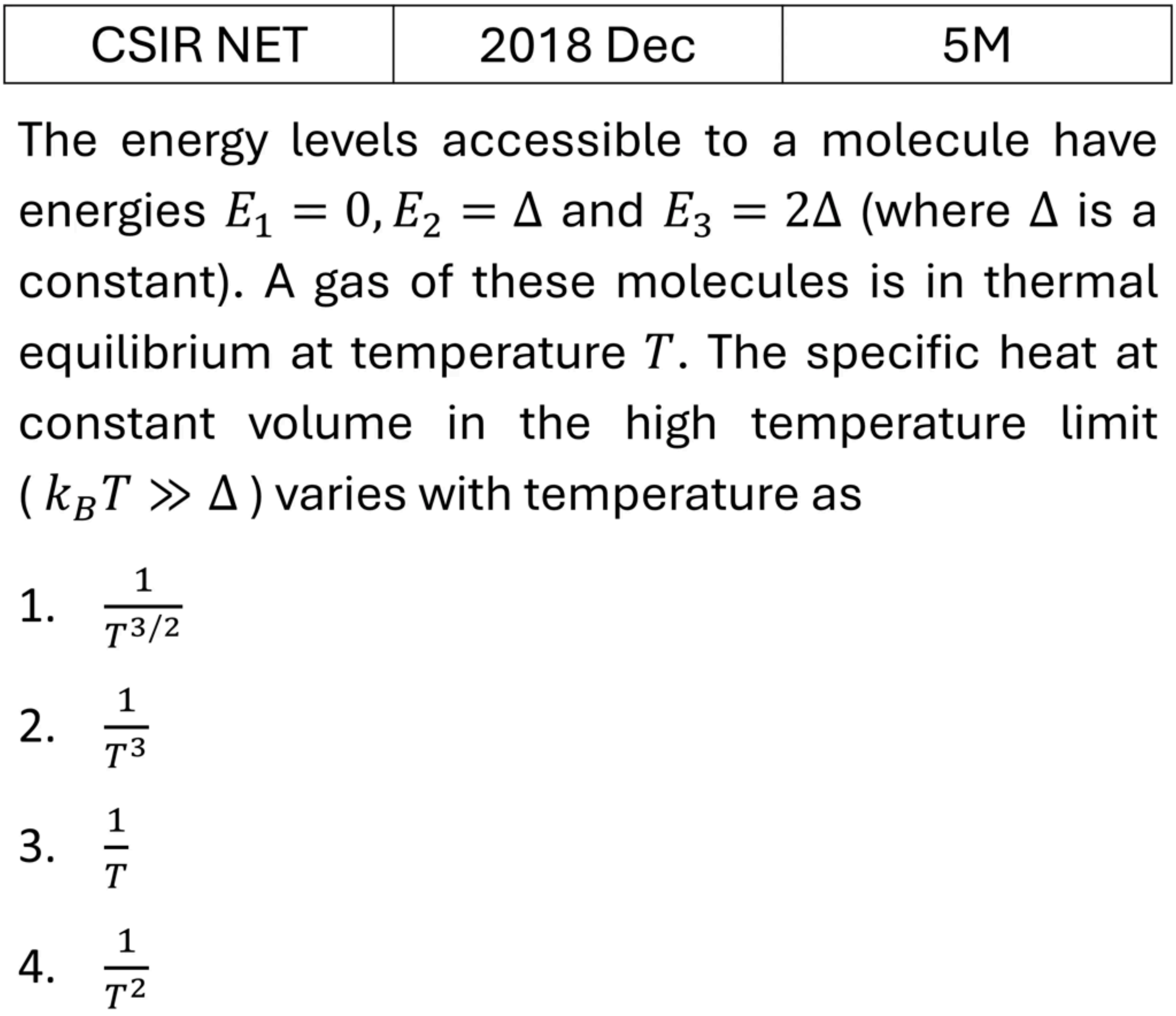
CSIR NET	2018 Dec	3.5M

The vibrational motion of a diatomic molecule may be considered to be that of a simple harmonic oscillator with angular frequency ω. If a gas of these molecules is at temperature T, what is the probability that a randomly picked molecule will be found in its lowest vibrational state?

1. $1 - e^{-\frac{\hbar\omega}{k_B T}}$
2. $e^{-\frac{\hbar\omega}{2k_B T}}$
3. $\tan h\left(\frac{\hbar\omega}{k_B T}\right)$
4. $\frac{1}{2}\mathrm{cosech}\left(\frac{\hbar\omega}{2k_B T}\right)$

Q13. [Dec 2018] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



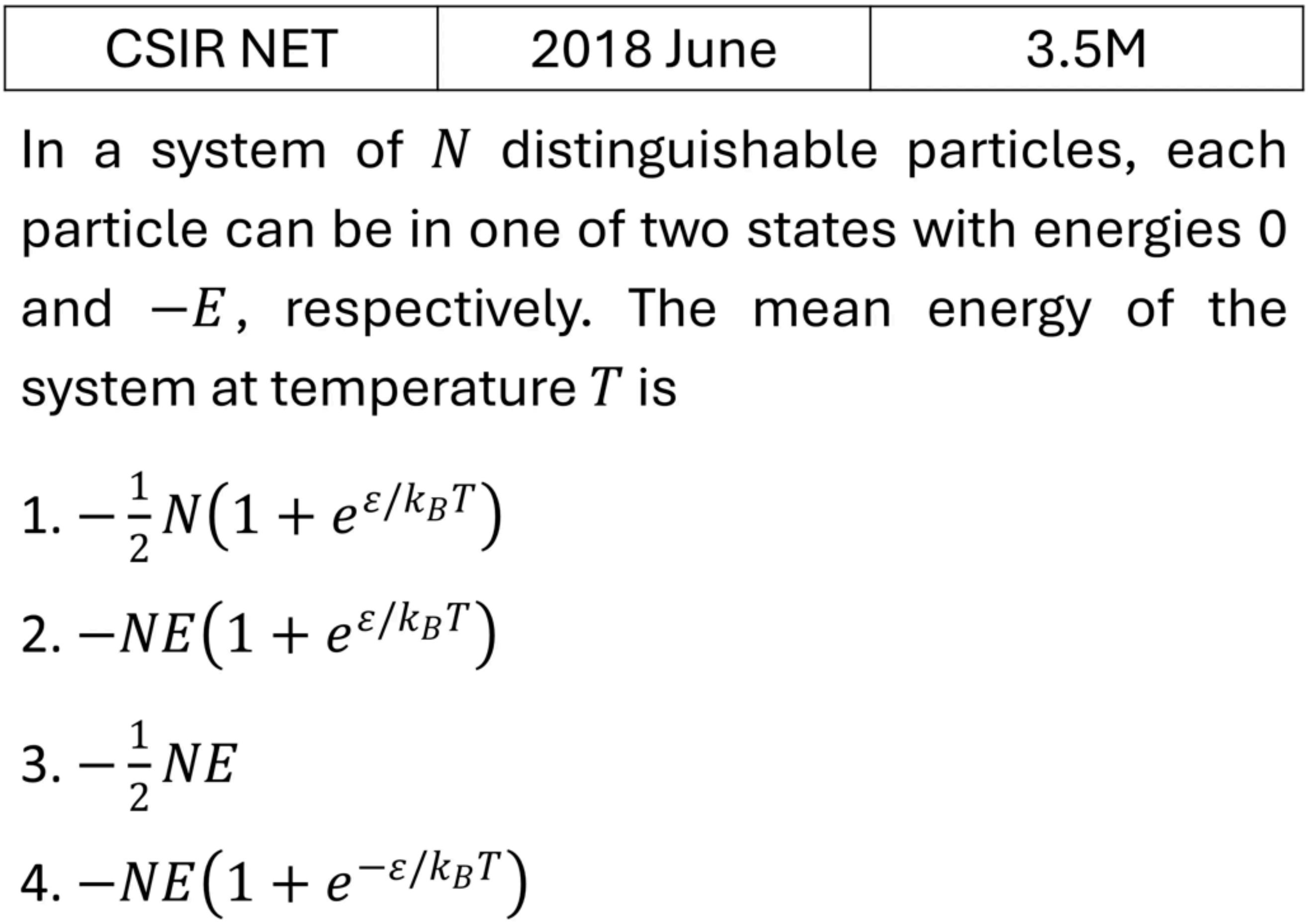
CSIR NET	2018 Dec	5M

The energy levels accessible to a molecule have energies $E_1 = 0, E_2 = \Delta$ and $E_3 = 2\Delta$ (where Δ is a constant). A gas of these molecules is in thermal equilibrium at temperature T. The specific heat at constant volume in the high temperature limit ($k_B T \gg \Delta$) varies with temperature as

1. $\frac{1}{T^{3/2}}$
2. $\frac{1}{T^3}$
3. $\frac{1}{T}$
4. $\frac{1}{T^2}$

Q14. [June 2018] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



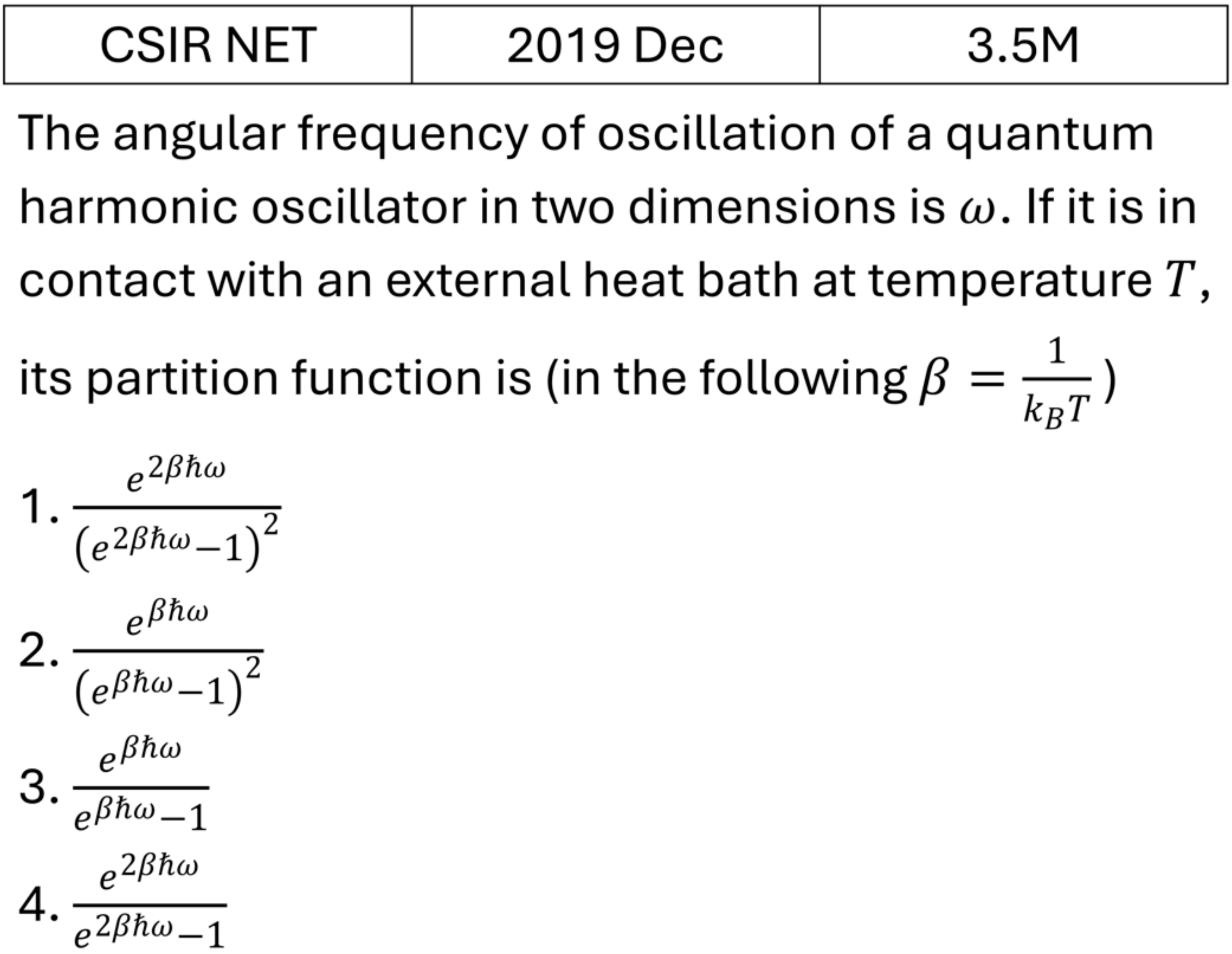
CSIR NET	2018 June	3.5M

In a system of N distinguishable particles, each particle can be in one of two states with energies 0 and $-E$, respectively. The mean energy of the system at temperature T is

1. $-\frac{1}{2}N\left(1+e^{\varepsilon/k_BT}\right)$
2. $-NE\left(1+e^{\varepsilon/k_BT}\right)$
3. $-\frac{1}{2}NE$
4. $-NE\left(1+e^{-\varepsilon/k_BT}\right)$

Q15. [Dec 2019] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



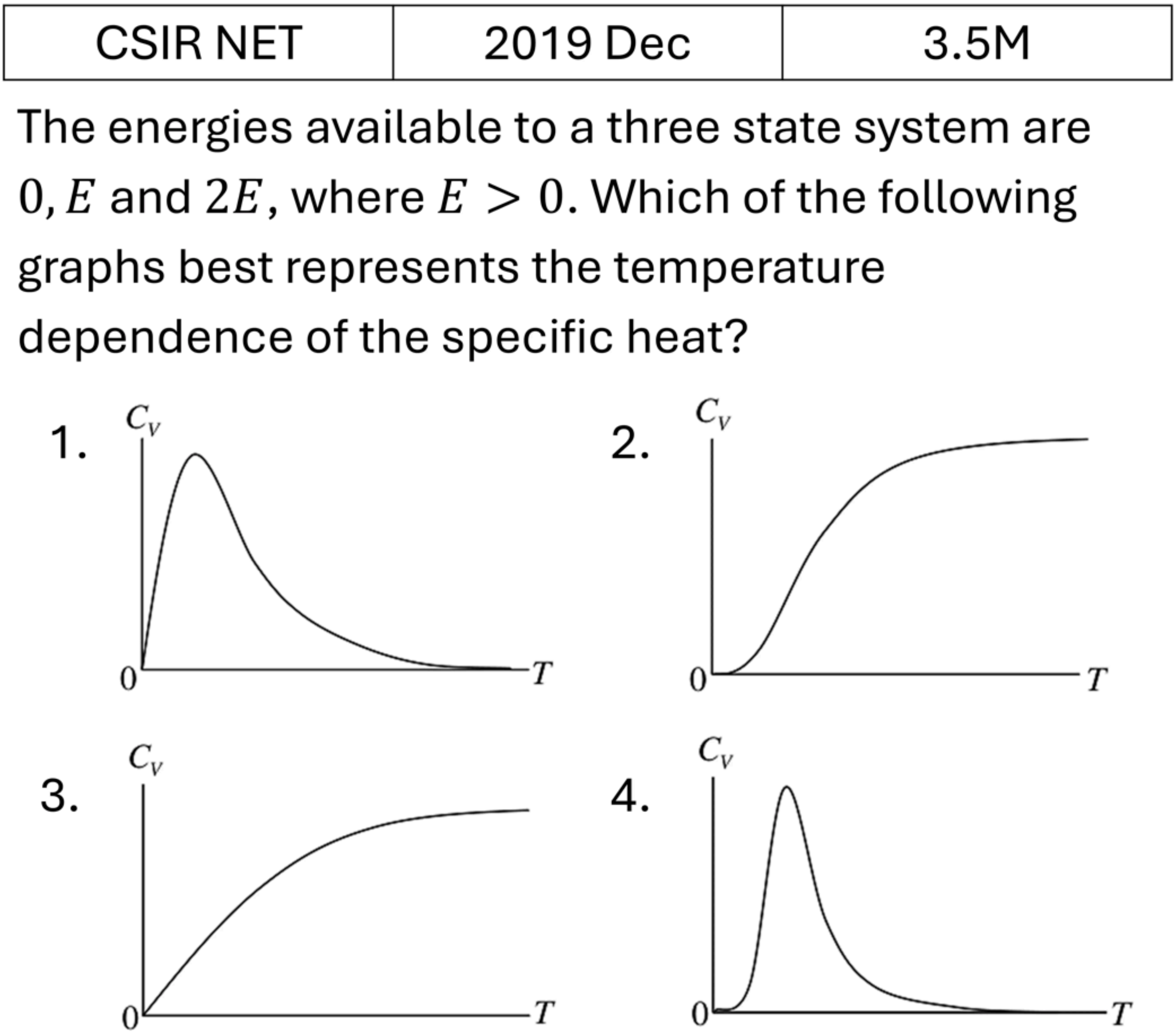
CSIR NET	2019 Dec	3.5M

The angular frequency of oscillation of a quantum harmonic oscillator in two dimensions is ω. If it is in contact with an external heat bath at temperature T, its partition function is (in the following $\beta = \frac{1}{k_B T}$)

1. $\frac{e^{2\beta\hbar\omega}}{\left(e^{2\beta\hbar\omega}-1\right)^2}$
2. $\frac{e^{\beta\hbar\omega}}{\left(e^{\beta\hbar\omega}-1\right)^2}$
3. $\frac{e^{\beta\hbar\omega}}{e^{\beta\hbar\omega}-1}$
4. $\frac{e^{2\beta\hbar\omega}}{e^{2\beta\hbar\omega}-1}$

Q16. [Dec 2019] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2019 Dec	3.5M

The energies available to a three state system are $0, E$ and $2E$, where $E > 0$. Which of the following graphs best represents the temperature dependence of the specific heat?

1.

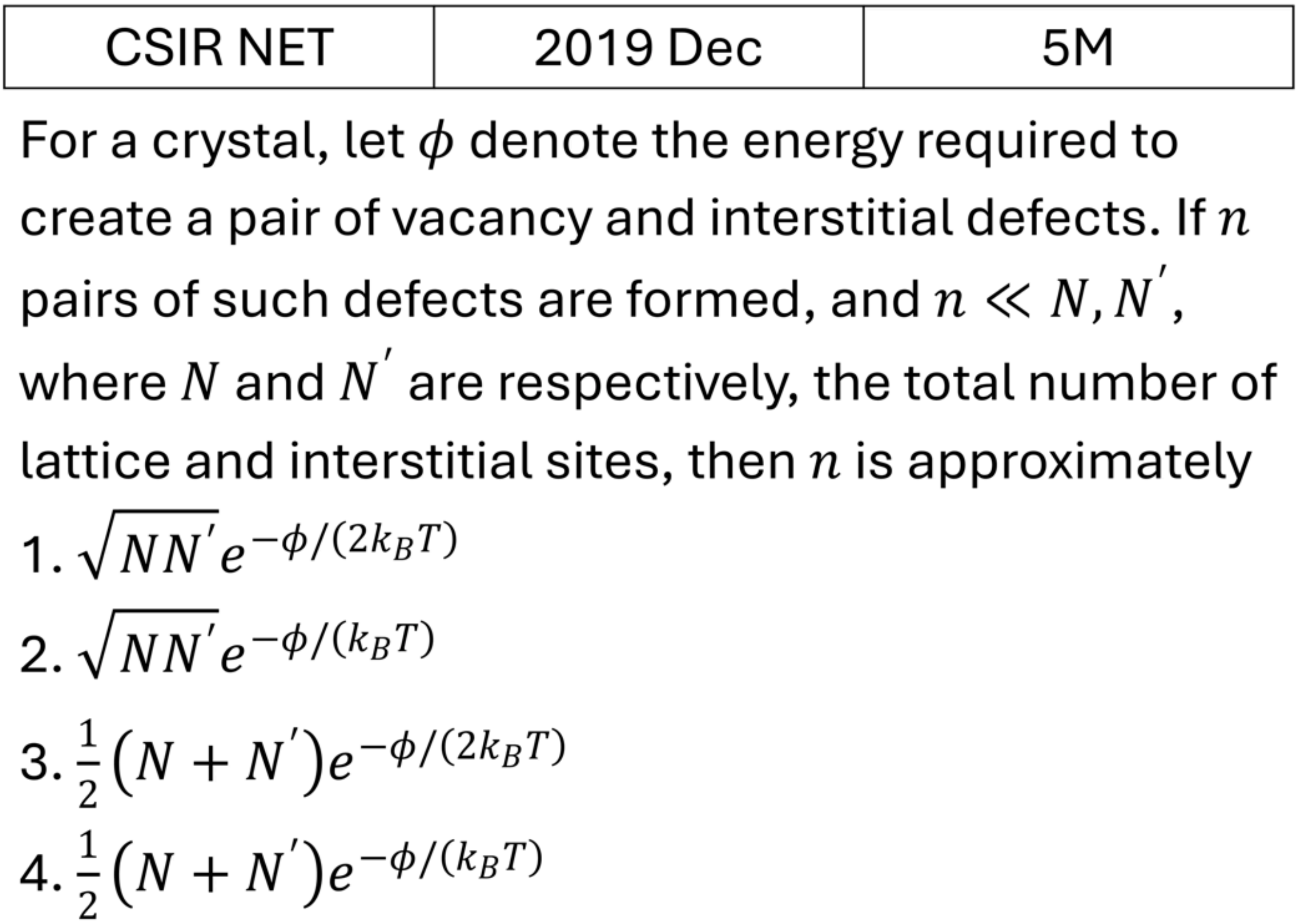
2.

3.

4.

Q17. [Dec 2019] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



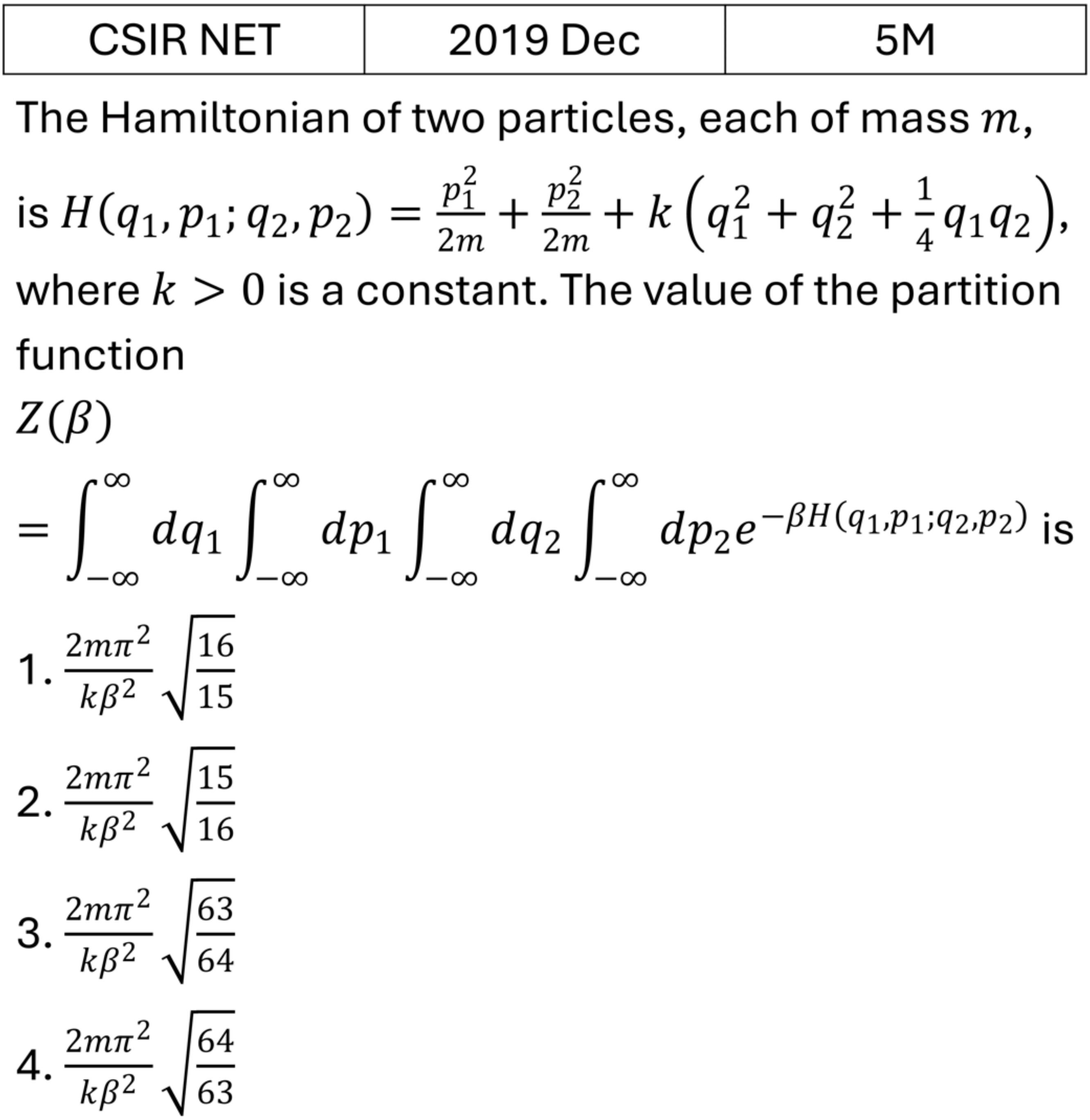
CSIR NET	2019 Dec	5M

For a crystal, let ϕ denote the energy required to create a pair of vacancy and interstitial defects. If n pairs of such defects are formed, and $n \ll N, N^{'}$, where N and $N^{'}$ are respectively, the total number of lattice and interstitial sites, then n is approximately

1. $\sqrt{NN'}e^{-\phi/(2k_BT)}$
2. $\sqrt{NN'}e^{-\phi/(k_BT)}$
3. $\frac{1}{2}(N + N^{'})e^{-\phi/(2k_BT)}$
4. $\frac{1}{2}(N + N^{'})e^{-\phi/(k_BT)}$

Q18. [Dec 2019] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2019 Dec	5M

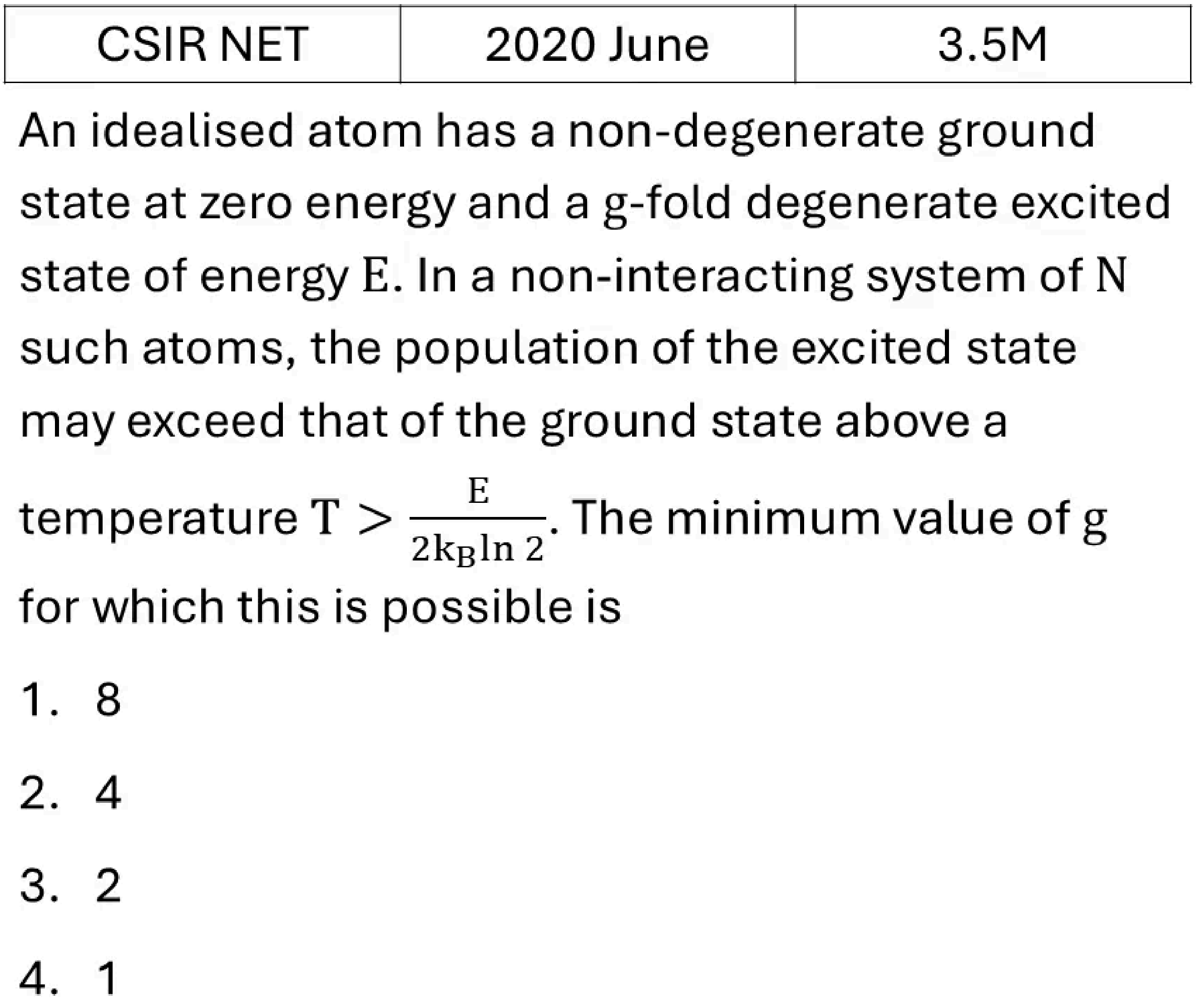
The Hamiltonian of two particles, each of mass m, is $H(q_1, p_1; q_2, p_2) = \frac{p_1^2}{2m} + \frac{p_2^2}{2m} + k\left(q_1^2 + q_2^2 + \frac{1}{4}q_1 q_2\right)$, where $k > 0$ is a constant. The value of the partition function

$$Z(\beta) = \int_{-\infty}^{\infty} dq_1 \int_{-\infty}^{\infty} dp_1 \int_{-\infty}^{\infty} dq_2 \int_{-\infty}^{\infty} dp_2 e^{-\beta H(q_1,p_1;q_2,p_2)}$$ is

1. $\frac{2m\pi^2}{k\beta^2}\sqrt{\frac{16}{15}}$
2. $\frac{2m\pi^2}{k\beta^2}\sqrt{\frac{15}{16}}$
3. $\frac{2m\pi^2}{k\beta^2}\sqrt{\frac{63}{64}}$
4. $\frac{2m\pi^2}{k\beta^2}\sqrt{\frac{64}{63}}$

Q19. [June 2020] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



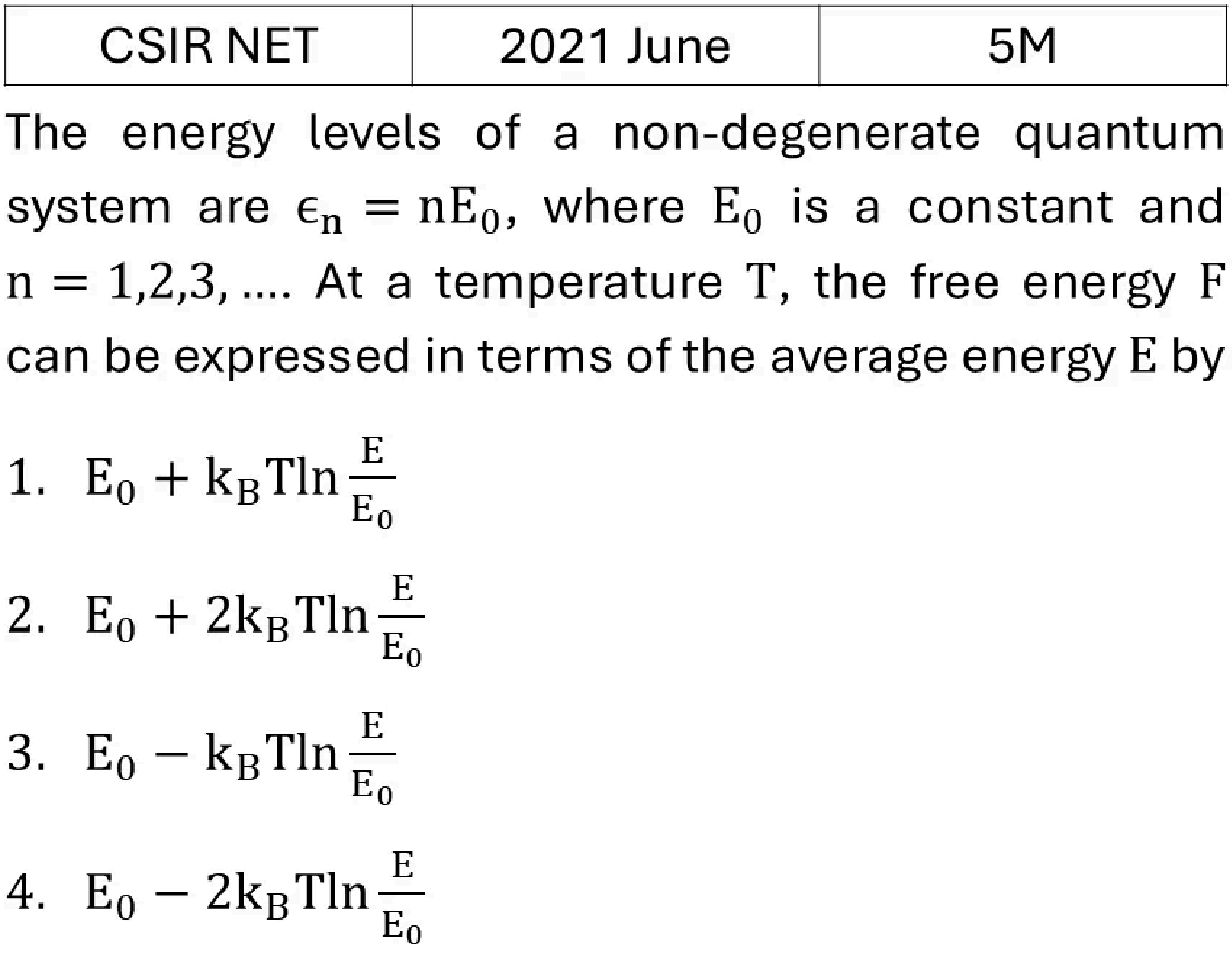
CSIR NET	2020 June	3.5M

An idealised atom has a non-degenerate ground state at zero energy and a g-fold degenerate excited state of energy E. In a non-interacting system of N such atoms, the population of the excited state may exceed that of the ground state above a temperature $T > \frac{E}{2k_B \ln 2}$. The minimum value of g for which this is possible is

1. 8
2. 4
3. 2
4. 1

Q20. [June 2021] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



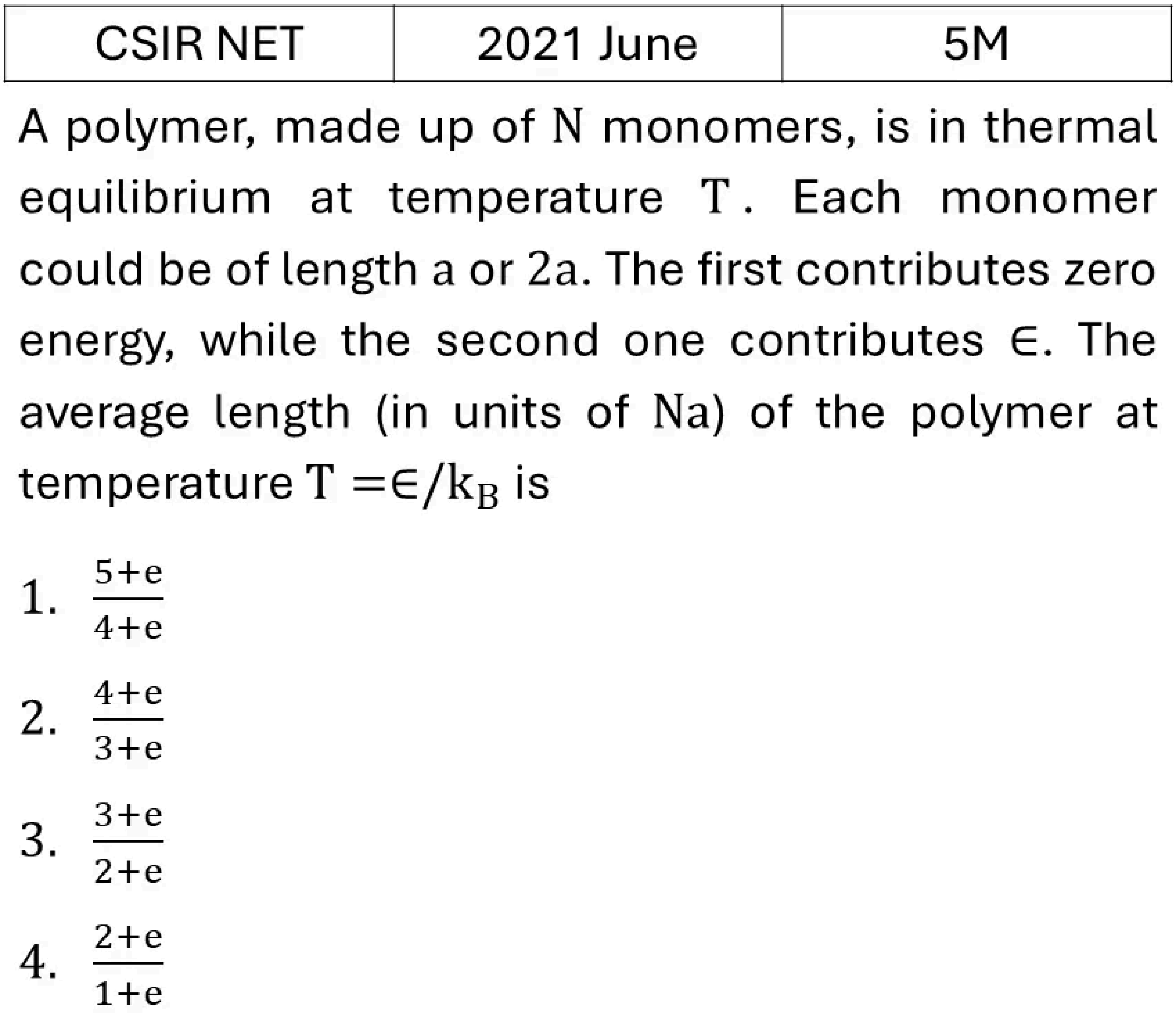
CSIR NET	2021 June	5M

The energy levels of a non-degenerate quantum system are $\epsilon_n = nE_0$, where E_0 is a constant and $n = 1,2,3,\dots$. At a temperature T, the free energy F can be expressed in terms of the average energy E by

1. $E_0 + k_B T \ln \frac{E}{E_0}$
2. $E_0 + 2k_B T \ln \frac{E}{E_0}$
3. $E_0 - k_B T \ln \frac{E}{E_0}$
4. $E_0 - 2k_B T \ln \frac{E}{E_0}$

Q21. [June 2021] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



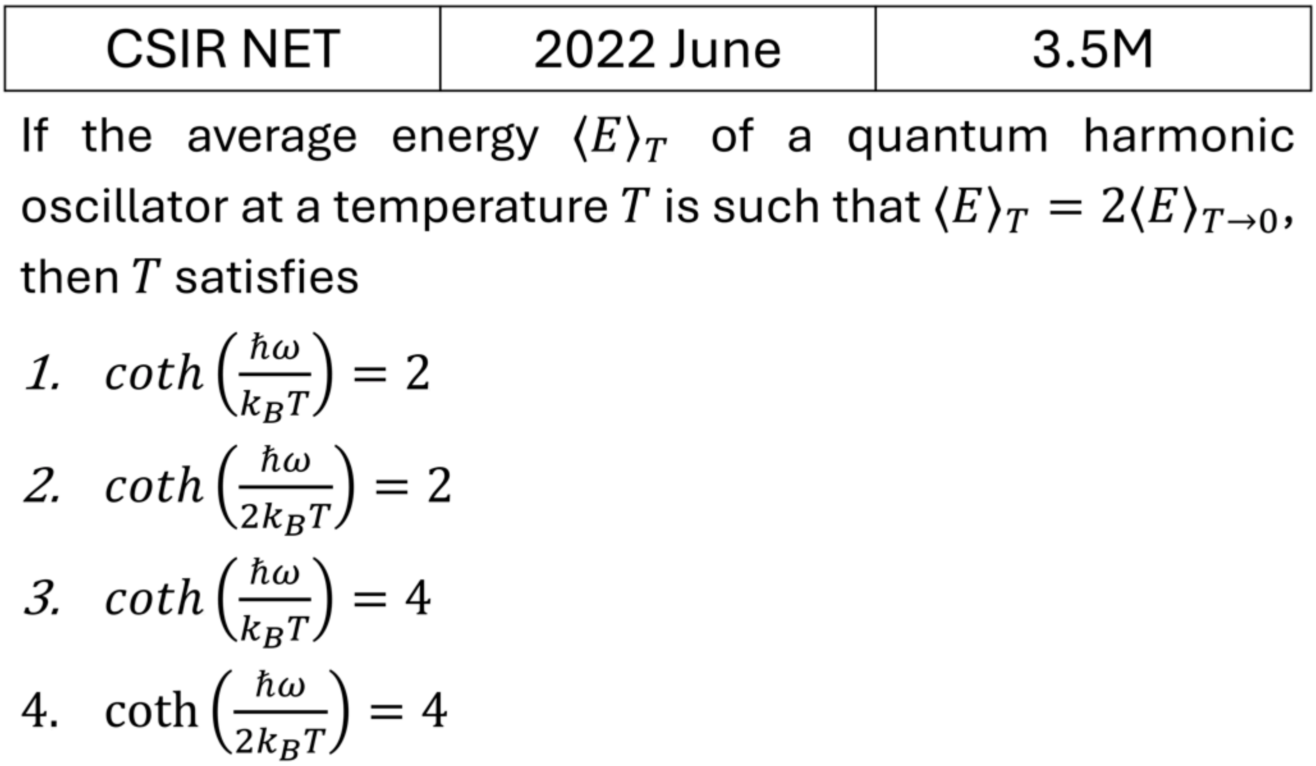
CSIR NET	2021 June	5M

A polymer, made up of N monomers, is in thermal equilibrium at temperature T. Each monomer could be of length a or $2a$. The first contributes zero energy, while the second one contributes $\in$. The average length (in units of Na) of the polymer at temperature $T = \in/k_B$ is

1. $\frac{5+e}{4+e}$
2. $\frac{4+e}{3+e}$
3. $\frac{3+e}{2+e}$
4. $\frac{2+e}{1+e}$

Q22. [June 2022] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2022 June	3.5M

If the average energy $\langle E\rangle_T$ of a quantum harmonic oscillator at a temperature T is such that $\langle E\rangle_T = 2\langle E\rangle_{T\to 0}$, then T satisfies

1. $coth\left(\frac{\hbar\omega}{k_B T}\right) = 2$
2. $coth\left(\frac{\hbar\omega}{2k_B T}\right) = 2$
3. $coth\left(\frac{\hbar\omega}{k_B T}\right) = 4$
4. $\coth\left(\frac{\hbar\omega}{2k_B T}\right) = 4$

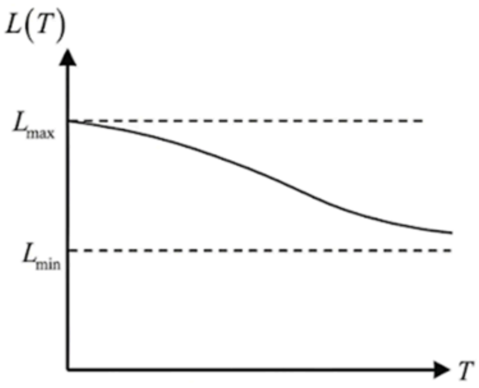
Q23. [June 2022] . 3.5 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2022 June	3.5M

An elastic rod has a low energy state of length $\mathrm{L}_{\mathrm{max}}$ and high energy state of length $\mathrm{L}_{\mathrm{min}}$. The best schematic representation of the temperature (T) dependence of the mean equilibrium length L(T) of the rod, is

1.



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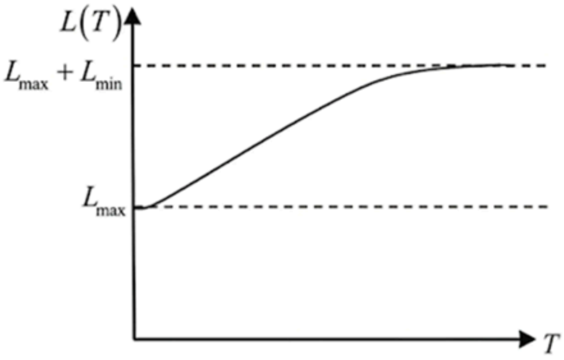
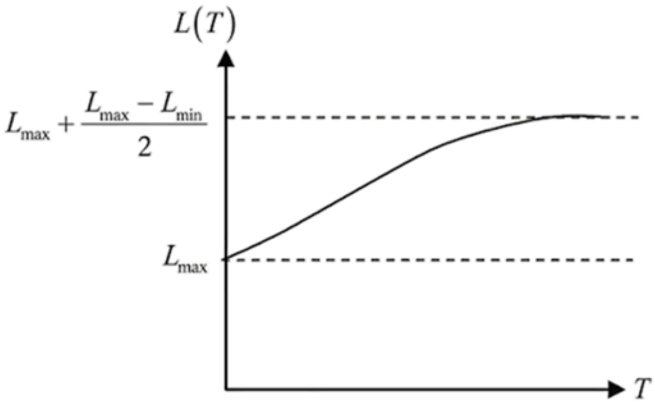
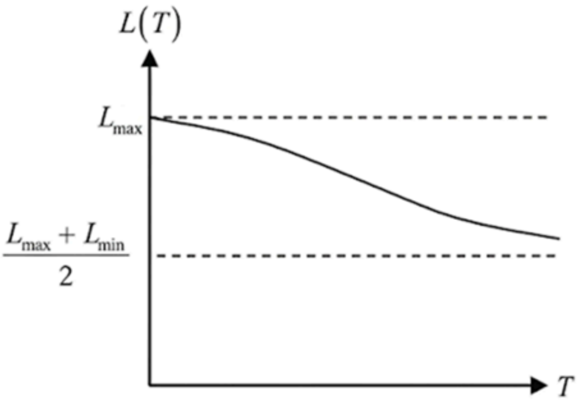


3.

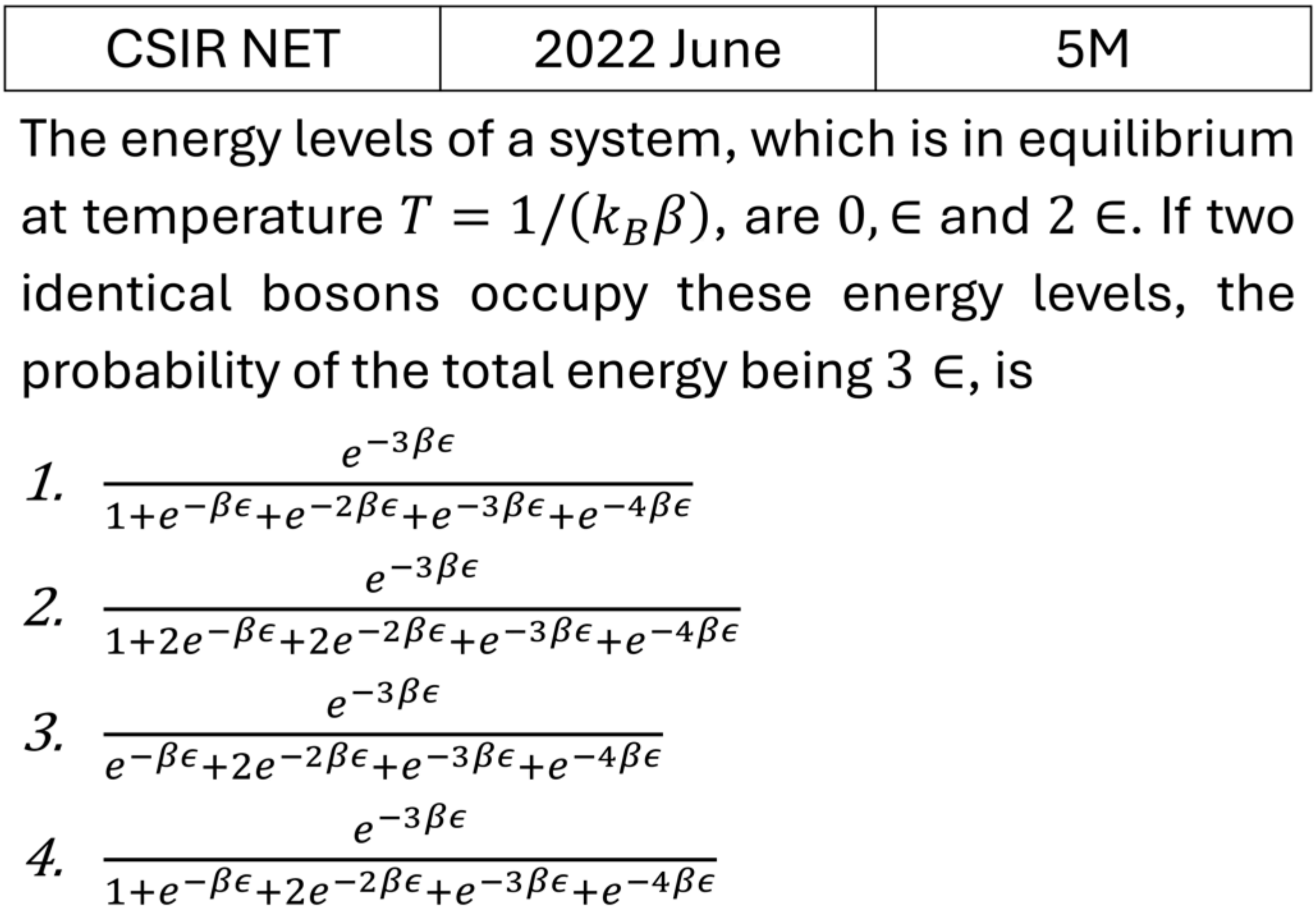


4.



Q24. [June 2022] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



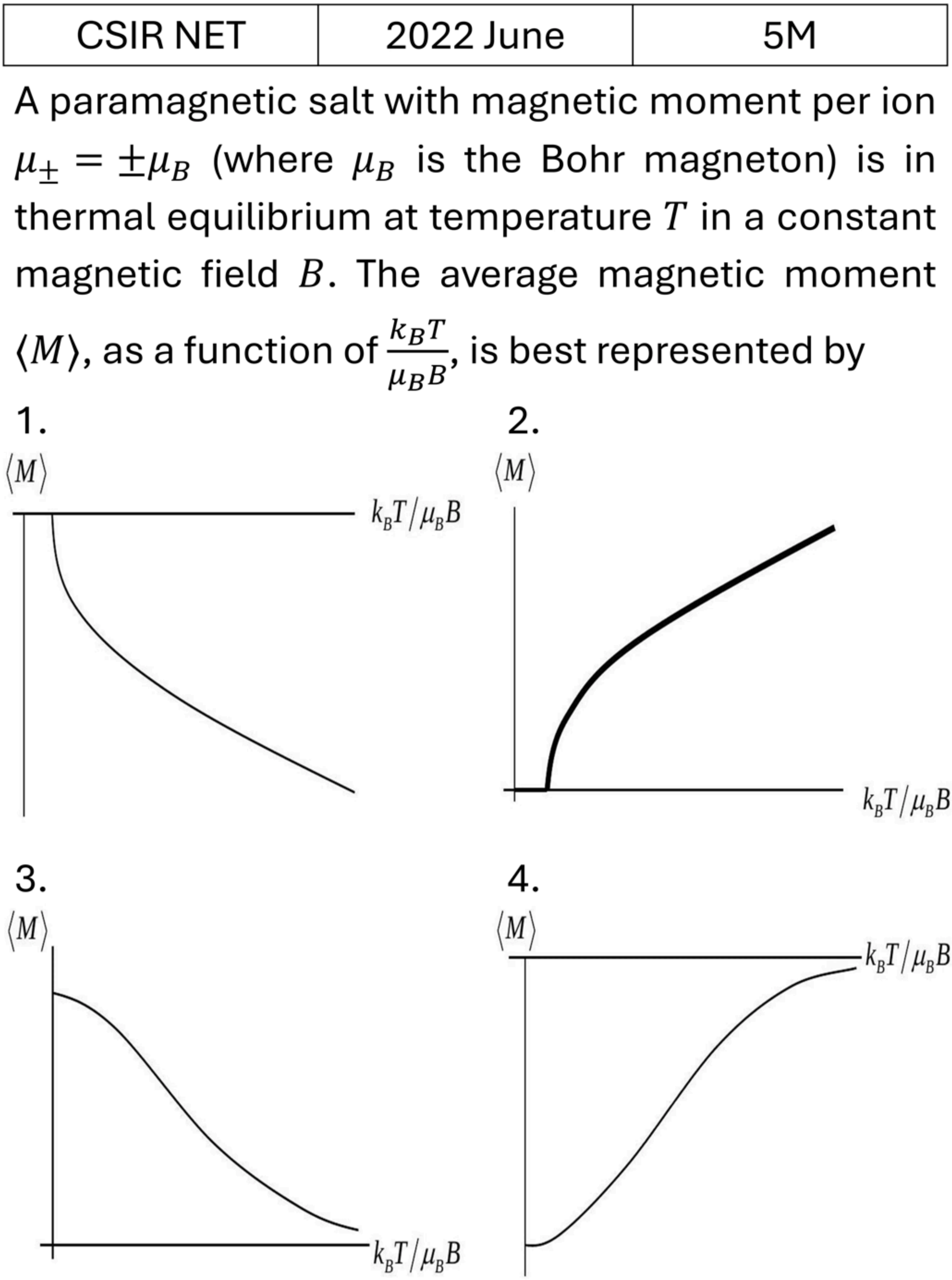
CSIR NET	2022 June	5M

The energy levels of a system, which is in equilibrium at temperature $T = 1/(k_B\beta)$, are $0, \in$ and $2 \in$. If two identical bosons occupy these energy levels, the probability of the total energy being $3 \in$, is

1. $\dfrac{e^{-3\beta\epsilon}}{1+e^{-\beta\epsilon}+e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$
2. $\dfrac{e^{-3\beta\epsilon}}{1+2e^{-\beta\epsilon}+2e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$
3. $\dfrac{e^{-3\beta\epsilon}}{e^{-\beta\epsilon}+2e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$
4. $\dfrac{e^{-3\beta\epsilon}}{1+e^{-\beta\epsilon}+2e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$

Q25. [June 2022] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2022 June	5M

A paramagnetic salt with magnetic moment per ion $\mu_{\pm} = \pm\mu_B$ (where μ_B is the Bohr magneton) is in thermal equilibrium at temperature T in a constant magnetic field B. The average magnetic moment $\langle M\rangle$, as a function of $\frac{k_BT}{\mu_BB}$, is best represented by

1.

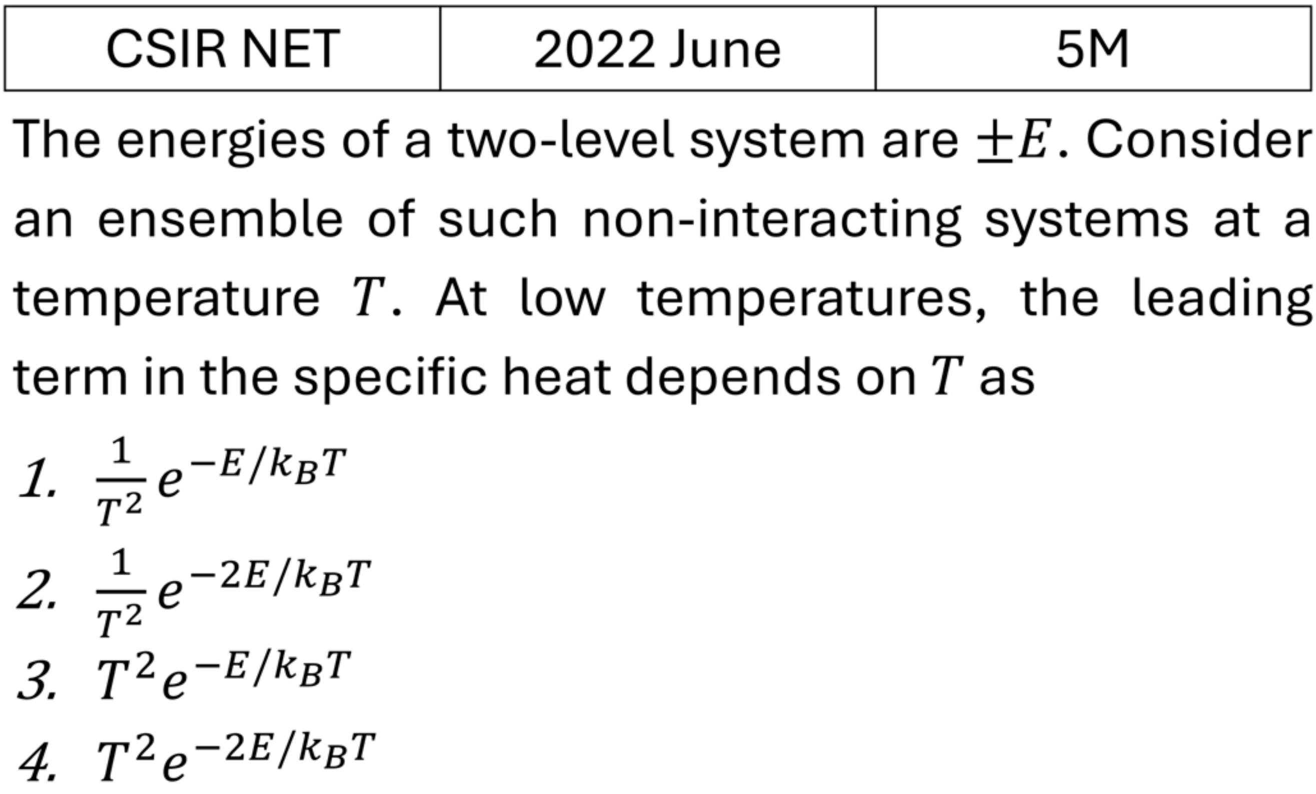
2.

3.

4.

Q26. [June 2022] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



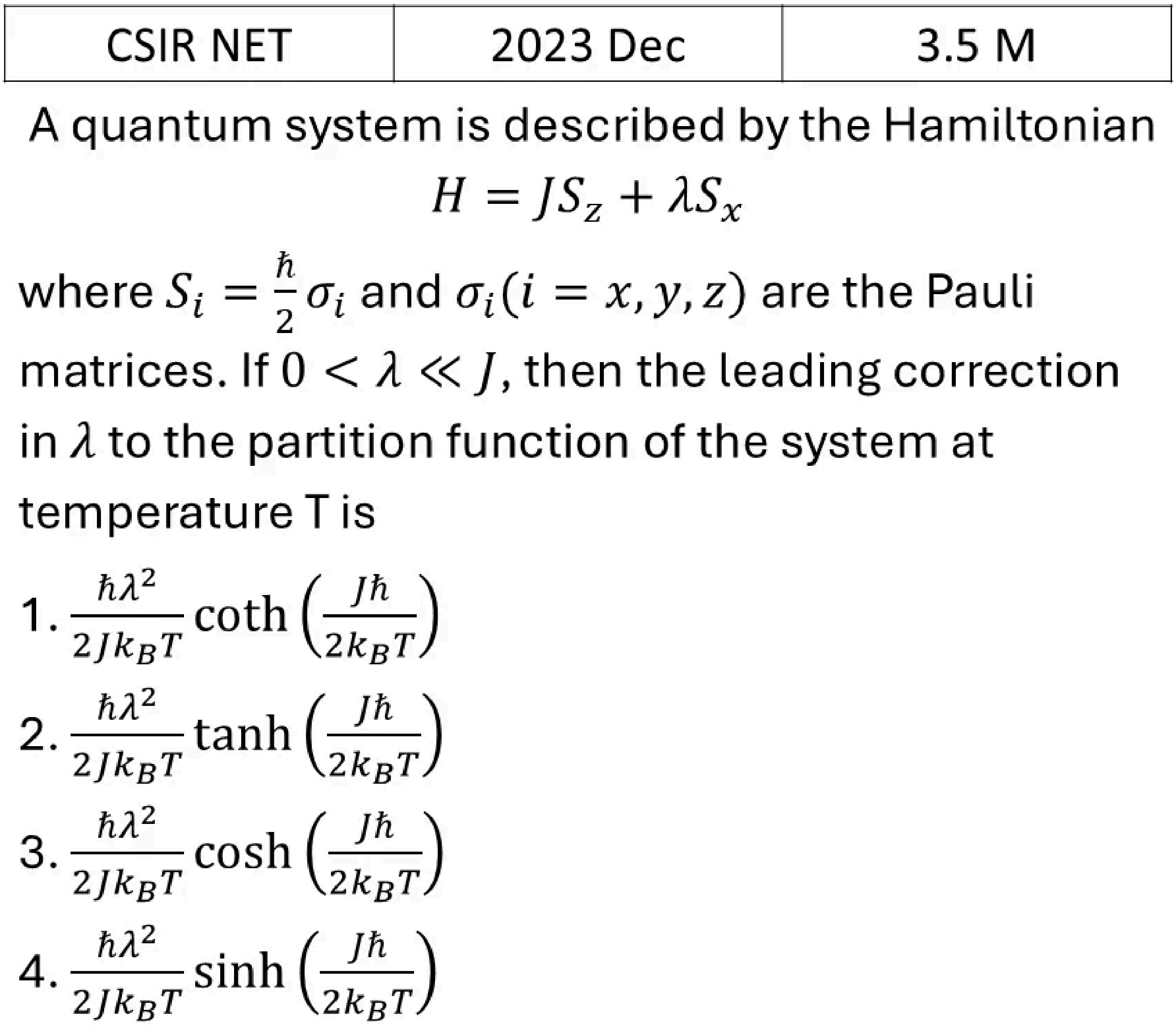
CSIR NET	2022 June	5M

The energies of a two-level system are $\pm E$. Consider an ensemble of such non-interacting systems at a temperature T. At low temperatures, the leading term in the specific heat depends on T as

1. $\frac{1}{T^2}e^{-E/k_BT}$
2. $\frac{1}{T^2}e^{-2E/k_BT}$
3. T^2e^{-E/k_BT}
4. T^2e^{-2E/k_BT}

Q27. [Dec 2023] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2023 Dec	3.5 M

A quantum system is described by the Hamiltonian

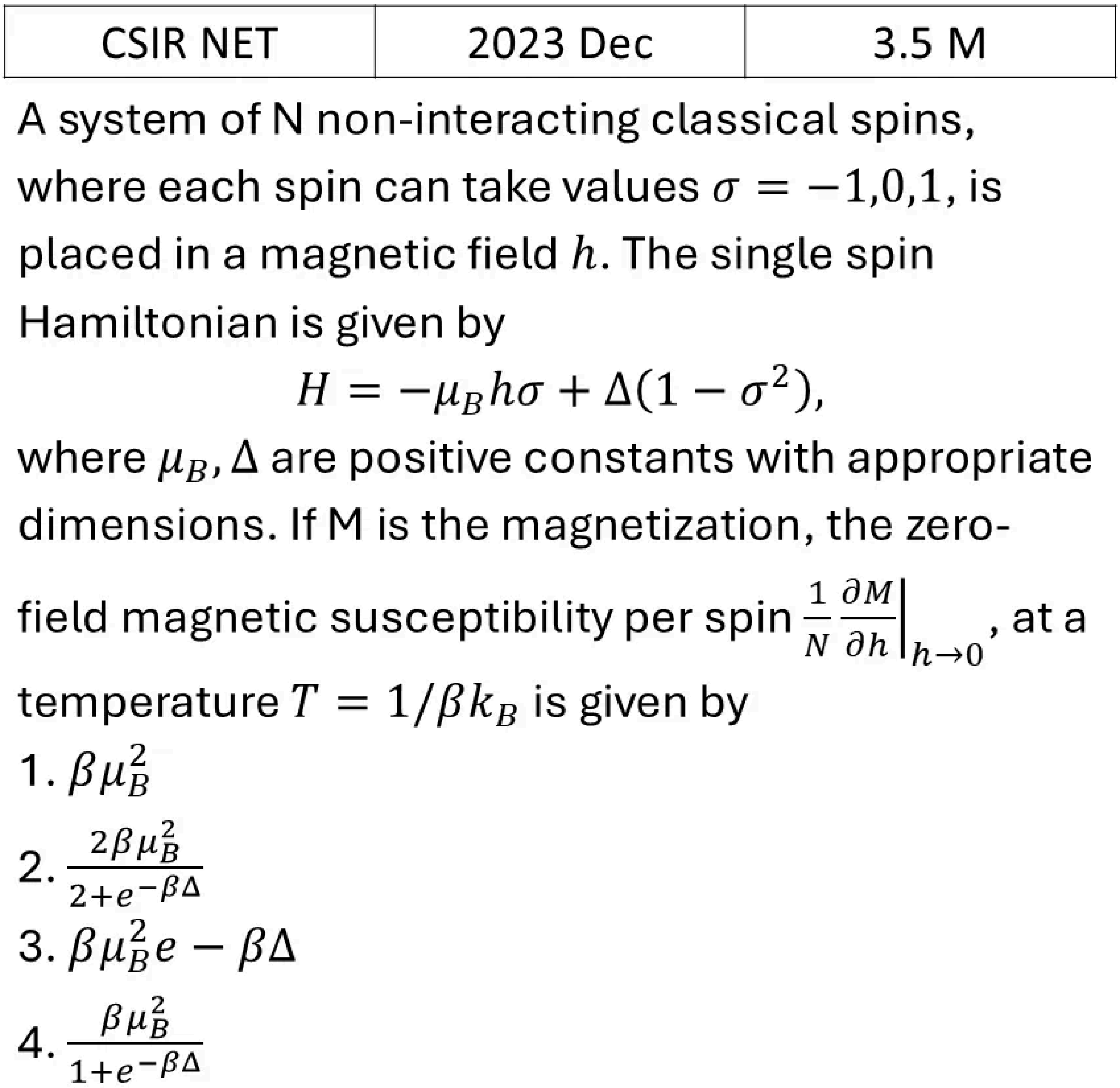
$$H = JS_z + \lambda S_x$$

where $S_i = \frac{\hbar}{2}\sigma_i$ and $\sigma_i (i = x, y, z)$ are the Pauli matrices. If $0 < \lambda \ll J$, then the leading correction in λ to the partition function of the system at temperature T is

1. $\frac{\hbar\lambda^2}{2Jk_BT}\coth\left(\frac{J\hbar}{2k_BT}\right)$
2. $\frac{\hbar\lambda^2}{2Jk_BT}\tanh\left(\frac{J\hbar}{2k_BT}\right)$
3. $\frac{\hbar\lambda^2}{2Jk_BT}\cosh\left(\frac{J\hbar}{2k_BT}\right)$
4. $\frac{\hbar\lambda^2}{2Jk_BT}\sinh\left(\frac{J\hbar}{2k_BT}\right)$

Q28. [Dec 2023] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2023 Dec	3.5 M

A system of N non-interacting classical spins, where each spin can take values $\sigma = -1,0,1$, is placed in a magnetic field h. The single spin Hamiltonian is given by

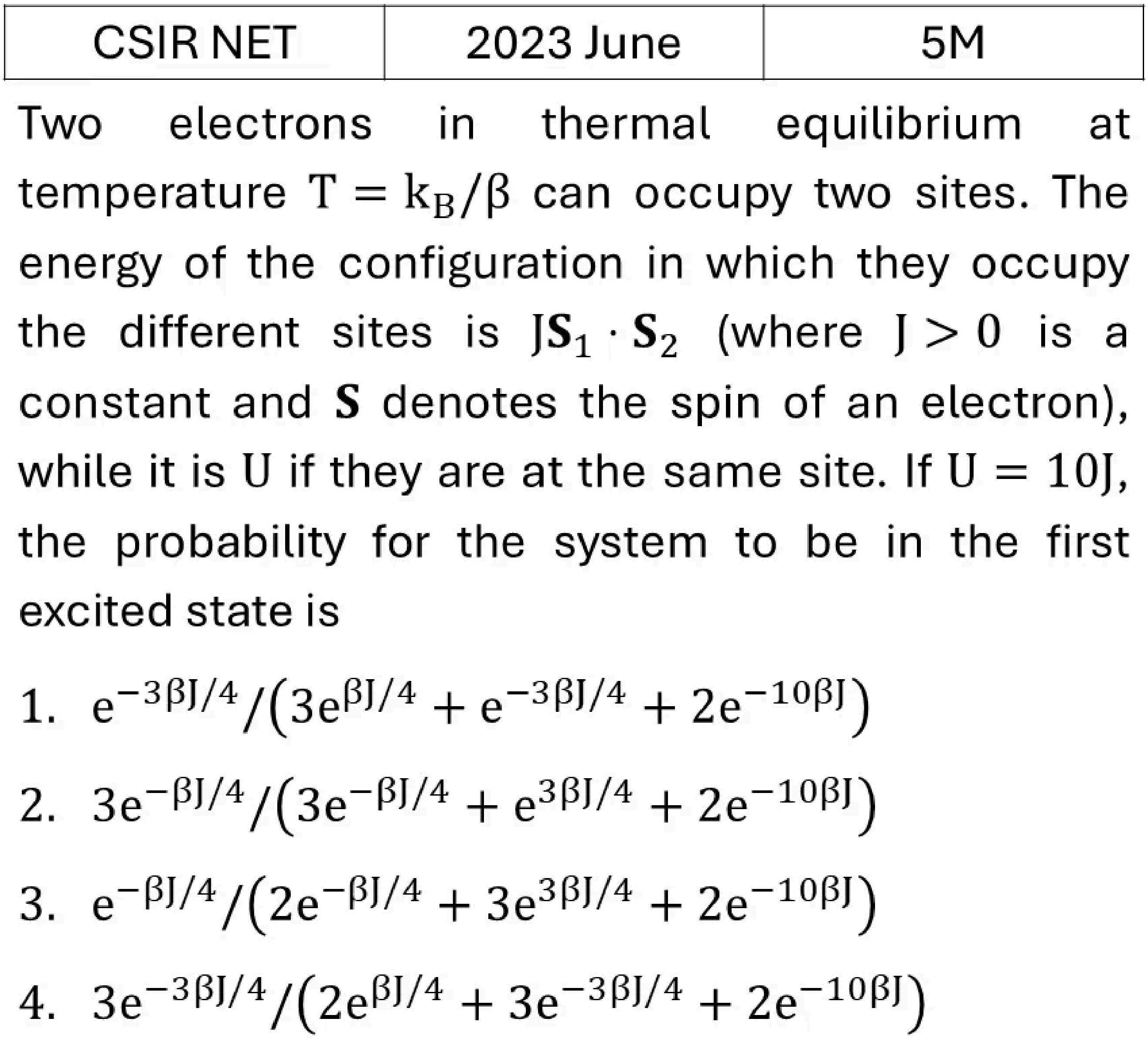
$$H = -\mu_B h\sigma + \Delta(1 - \sigma^2),$$

where μ_B, Δ are positive constants with appropriate dimensions. If M is the magnetization, the zero-field magnetic susceptibility per spin $\frac{1}{N}\frac{\partial M}{\partial h}\Big|_{h\to 0}$, at a temperature $T = 1/\beta k_B$ is given by

1. $\beta\mu_B^2$
2. $\frac{2\beta\mu_B^2}{2+e^{-\beta\Delta}}$
3. $\beta\mu_B^2 e - \beta\Delta$
4. $\frac{\beta\mu_B^2}{1+e^{-\beta\Delta}}$

Q29. [June 2023] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



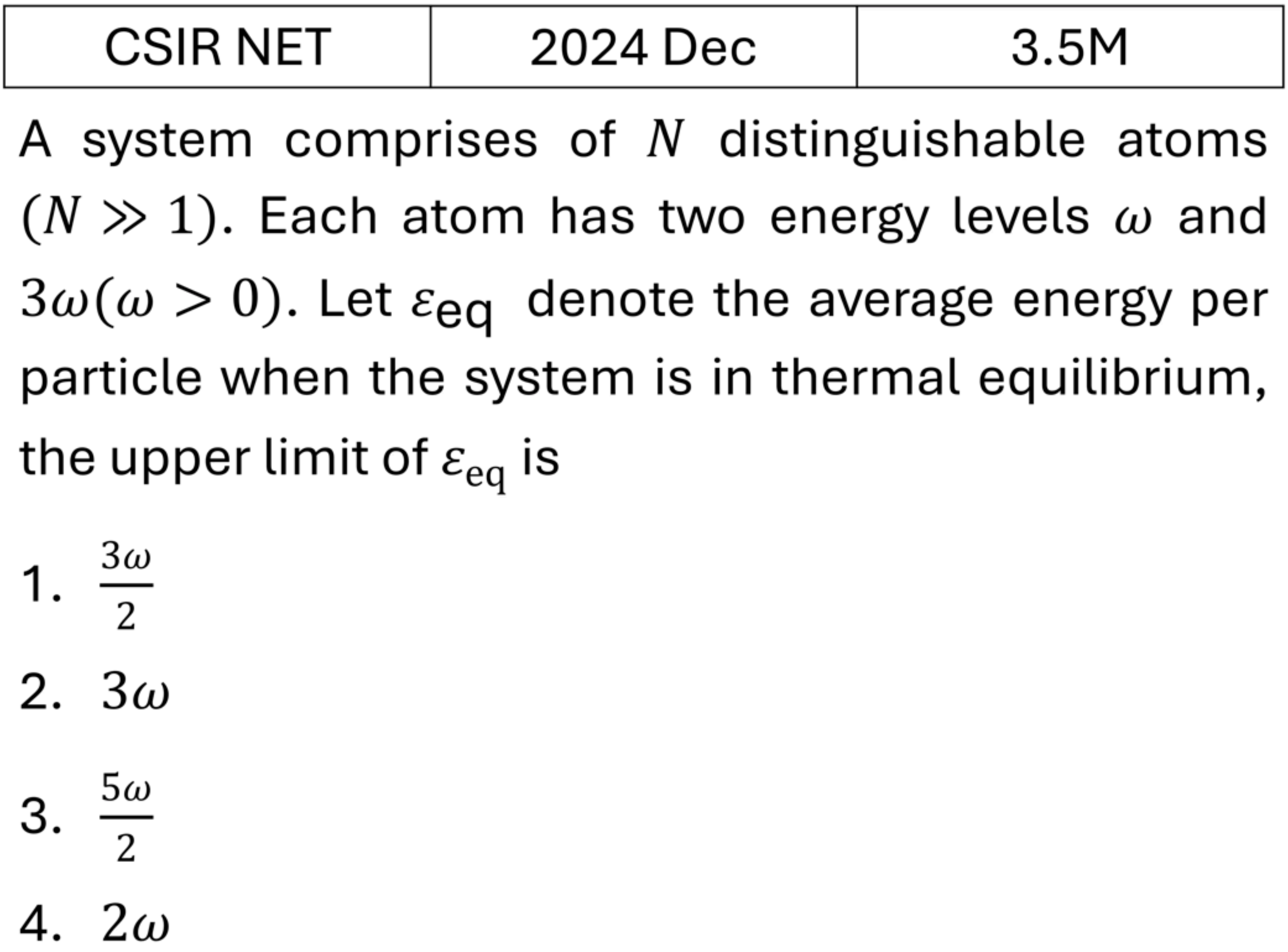
CSIR NET	2023 June	5M

Two electrons in thermal equilibrium at temperature $T = k_B/\beta$ can occupy two sites. The energy of the configuration in which they occupy the different sites is $J\boldsymbol{S}_1 \cdot \boldsymbol{S}_2$ (where $J > 0$ is a constant and $\boldsymbol{S}$ denotes the spin of an electron), while it is U if they are at the same site. If $U = 10J$, the probability for the system to be in the first excited state is

1. $e^{-3\beta J/4}/\left(3e^{\beta J/4} + e^{-3\beta J/4} + 2e^{-10\beta J}\right)$
2. $3e^{-\beta J/4}/\left(3e^{-\beta J/4} + e^{3\beta J/4} + 2e^{-10\beta J}\right)$
3. $e^{-\beta J/4}/\left(2e^{-\beta J/4} + 3e^{3\beta J/4} + 2e^{-10\beta J}\right)$
4. $3e^{-3\beta J/4}/\left(2e^{\beta J/4} + 3e^{-3\beta J/4} + 2e^{-10\beta J}\right)$

Q30. [Dec 2024] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



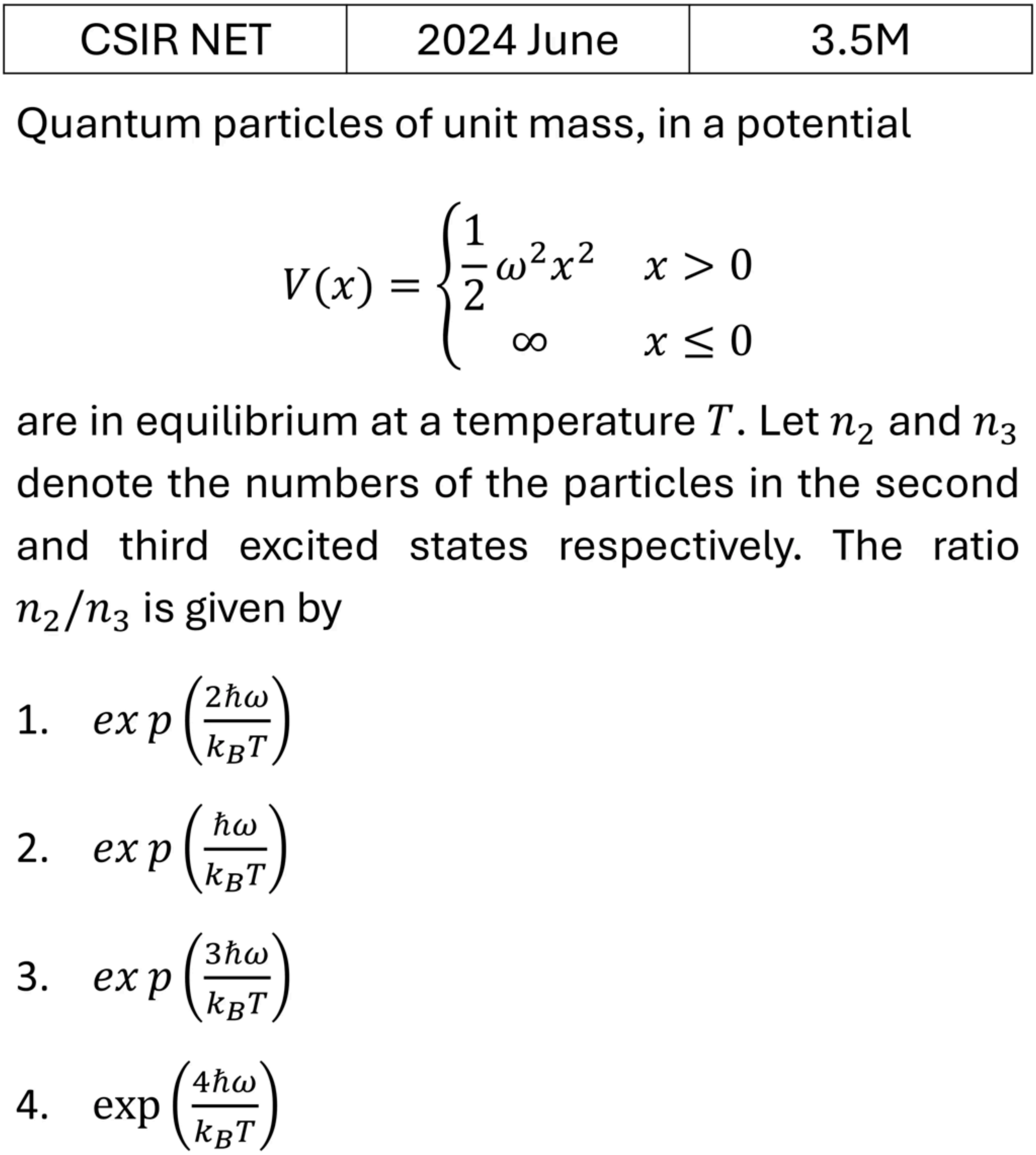
CSIR NET	2024 Dec	3.5M

A system comprises of N distinguishable atoms $(N \gg 1)$. Each atom has two energy levels ω and $3\omega (\omega > 0)$. Let ε_{eq} denote the average energy per particle when the system is in thermal equilibrium, the upper limit of ε_{eq} is

1. $\frac{3\omega}{2}$
2. 3ω
3. $\frac{5\omega}{2}$
4. 2ω

Q31. [June 2024] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2024 June	3.5M

Quantum particles of unit mass, in a potential

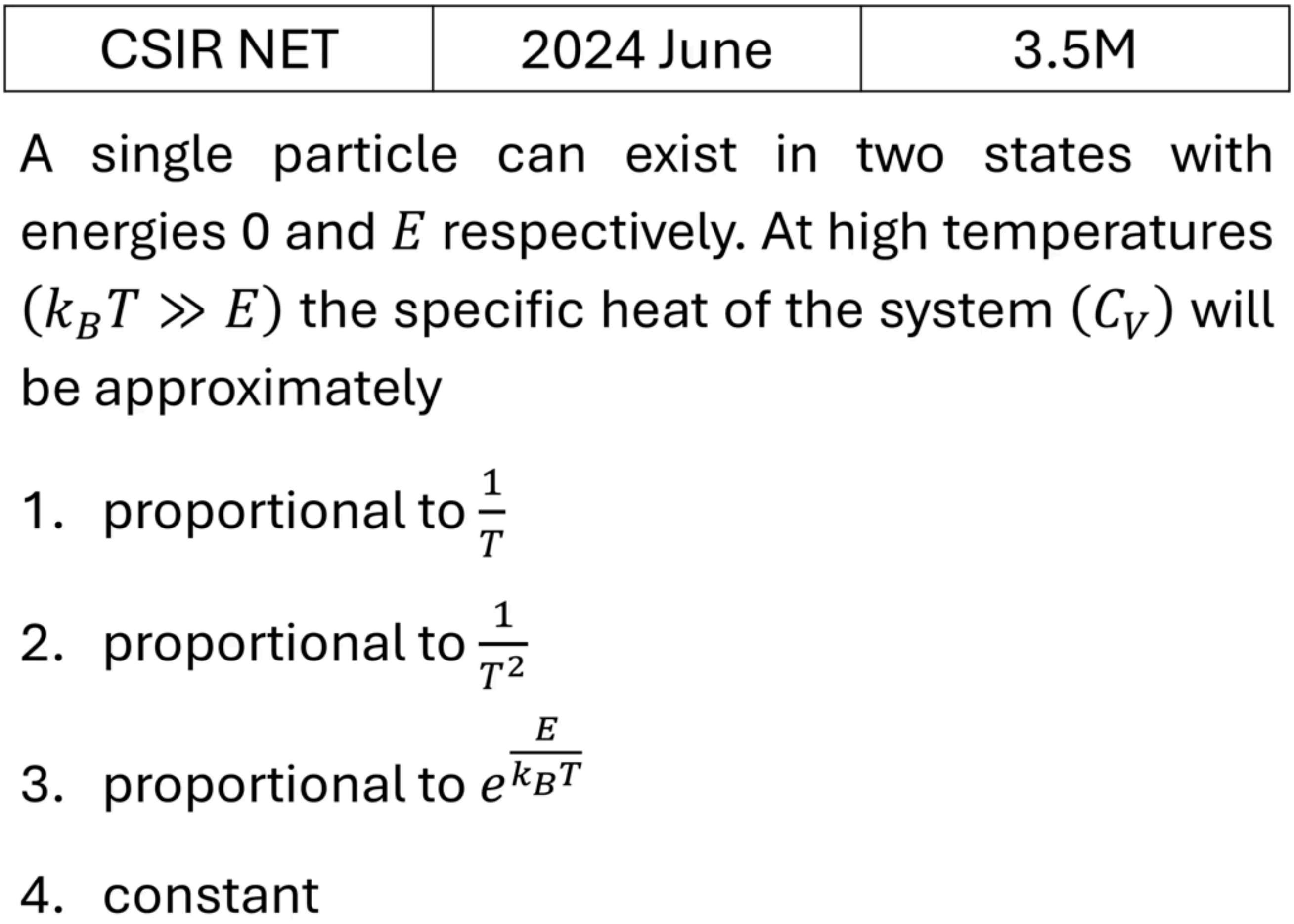
$$V(x) = \begin{cases} \frac{1}{2}\omega^2 x^2 & x > 0 \\ \infty & x \leq 0 \end{cases}$$

are in equilibrium at a temperature T. Let n_2 and n_3 denote the numbers of the particles in the second and third excited states respectively. The ratio n_2/n_3 is given by

1. $exp\left(\frac{2\hbar\omega}{k_BT}\right)$
2. $exp\left(\frac{\hbar\omega}{k_BT}\right)$
3. $exp\left(\frac{3\hbar\omega}{k_BT}\right)$
4. $\exp\left(\frac{4\hbar\omega}{k_BT}\right)$

Q32. [June 2024] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



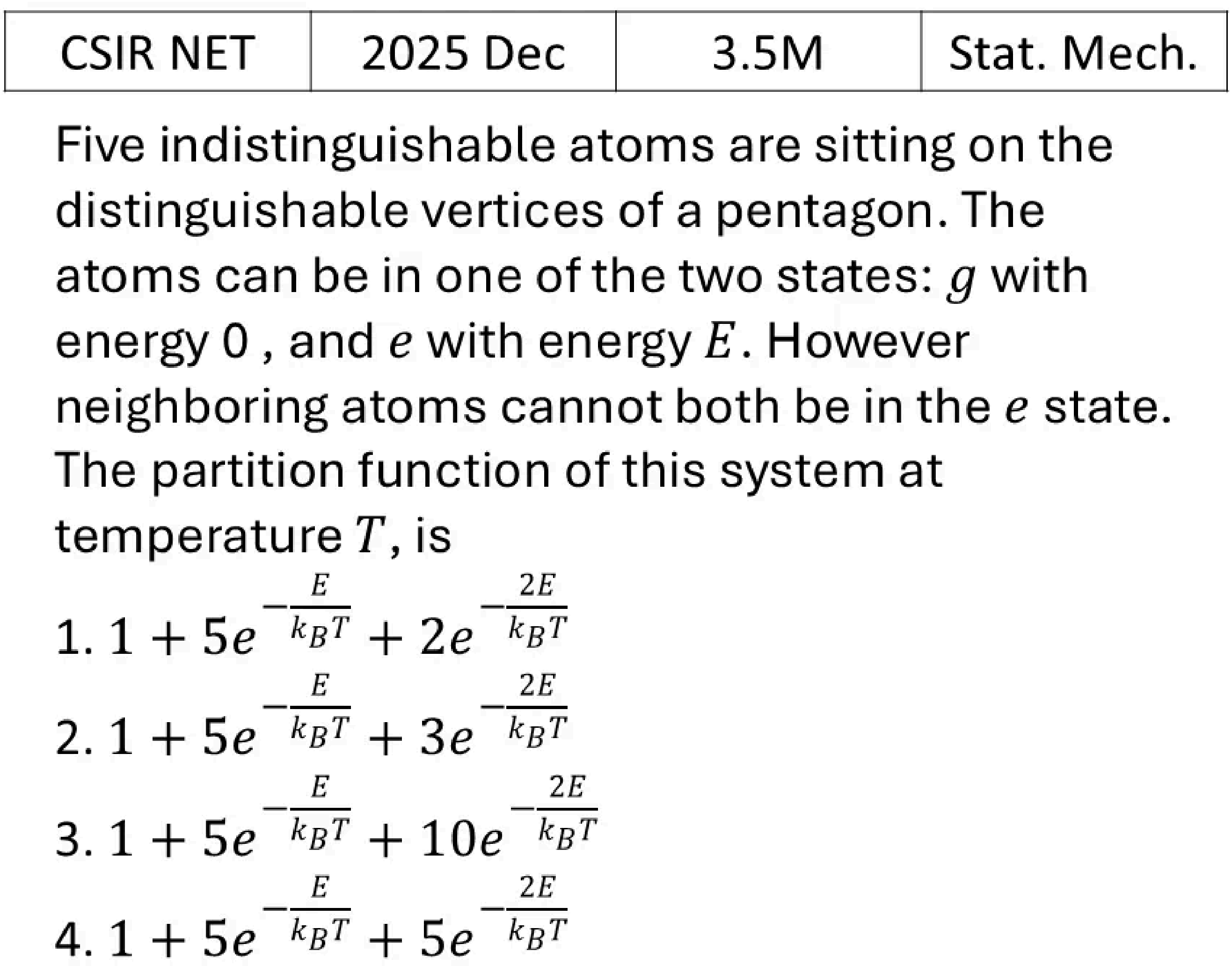
CSIR NET	2024 June	3.5M

A single particle can exist in two states with energies 0 and E respectively. At high temperatures $(k_B T \gg E)$ the specific heat of the system (C_V) will be approximately

1. proportional to $\frac{1}{T}$
2. proportional to $\frac{1}{T^2}$
3. proportional to $e^{\frac{E}{k_B T}}$
4. constant

Q33. [Dec 2025] . 3.5 marks

Statistical Mechanics > Canonical Ensemble



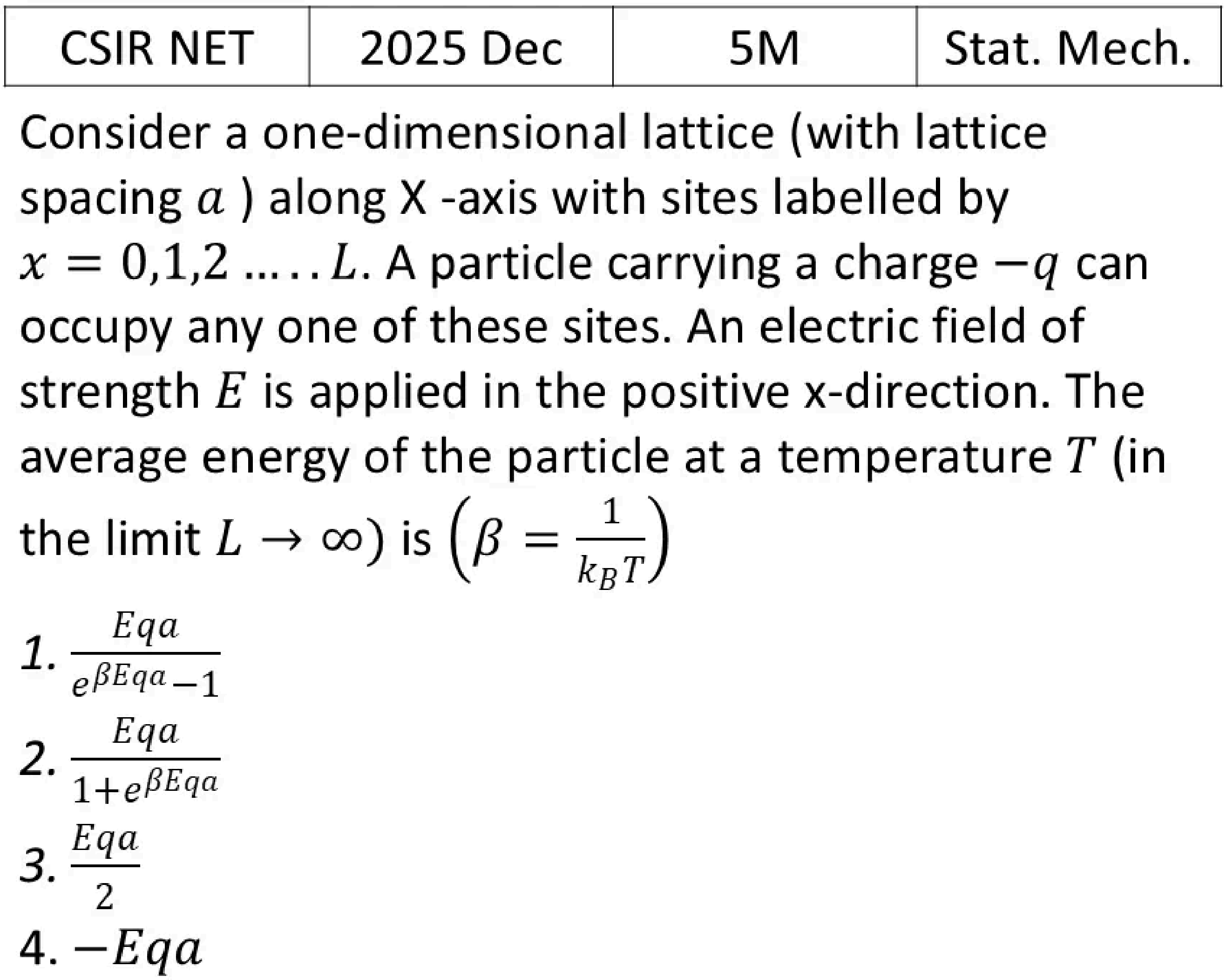
CSIR NET	2025 Dec	3.5M	Stat. Mech.

Five indistinguishable atoms are sitting on the distinguishable vertices of a pentagon. The atoms can be in one of the two states: g with energy 0 , and e with energy E. However neighboring atoms cannot both be in the e state. The partition function of this system at temperature T, is

1. $1 + 5e^{-\frac{E}{k_B T}} + 2e^{-\frac{2E}{k_B T}}$
2. $1 + 5e^{-\frac{E}{k_B T}} + 3e^{-\frac{2E}{k_B T}}$
3. $1 + 5e^{-\frac{E}{k_B T}} + 10e^{-\frac{2E}{k_B T}}$
4. $1 + 5e^{-\frac{E}{k_B T}} + 5e^{-\frac{2E}{k_B T}}$

Q34. [Dec 2025] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



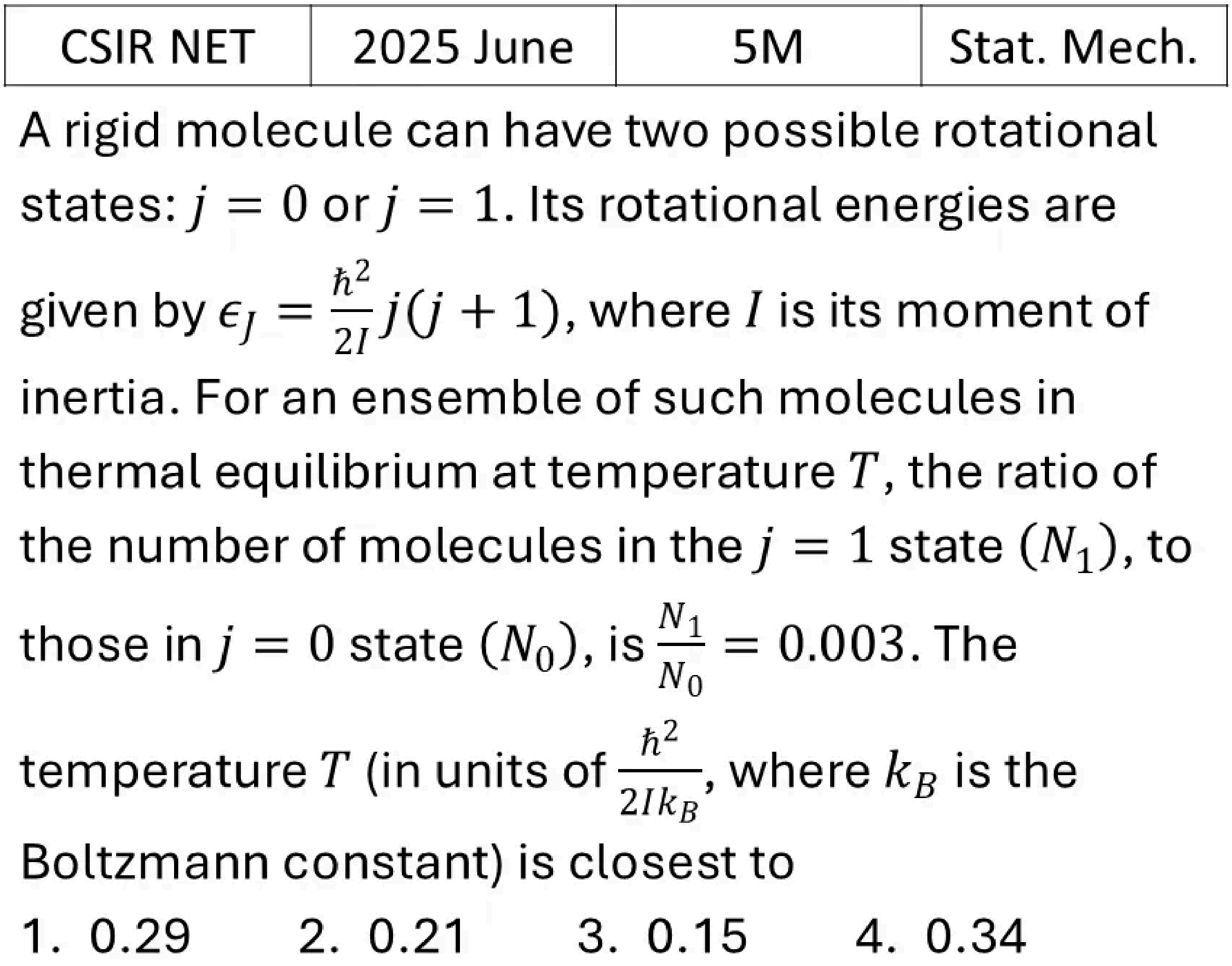
CSIR NET	2025 Dec	5M	Stat. Mech.

Consider a one-dimensional lattice (with lattice spacing a) along X -axis with sites labelled by $x = 0,1,2\ldots\ldots L$. A particle carrying a charge $-q$ can occupy any one of these sites. An electric field of strength E is applied in the positive x-direction. The average energy of the particle at a temperature T (in the limit $L \to \infty$) is $\left(\beta = \frac{1}{k_B T}\right)$

1. $\frac{Eqa}{e^{\beta Eqa}-1}$
2. $\frac{Eqa}{1+e^{\beta Eqa}}$
3. $\frac{Eqa}{2}$
4. $-Eqa$

Q35. [June 2025] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



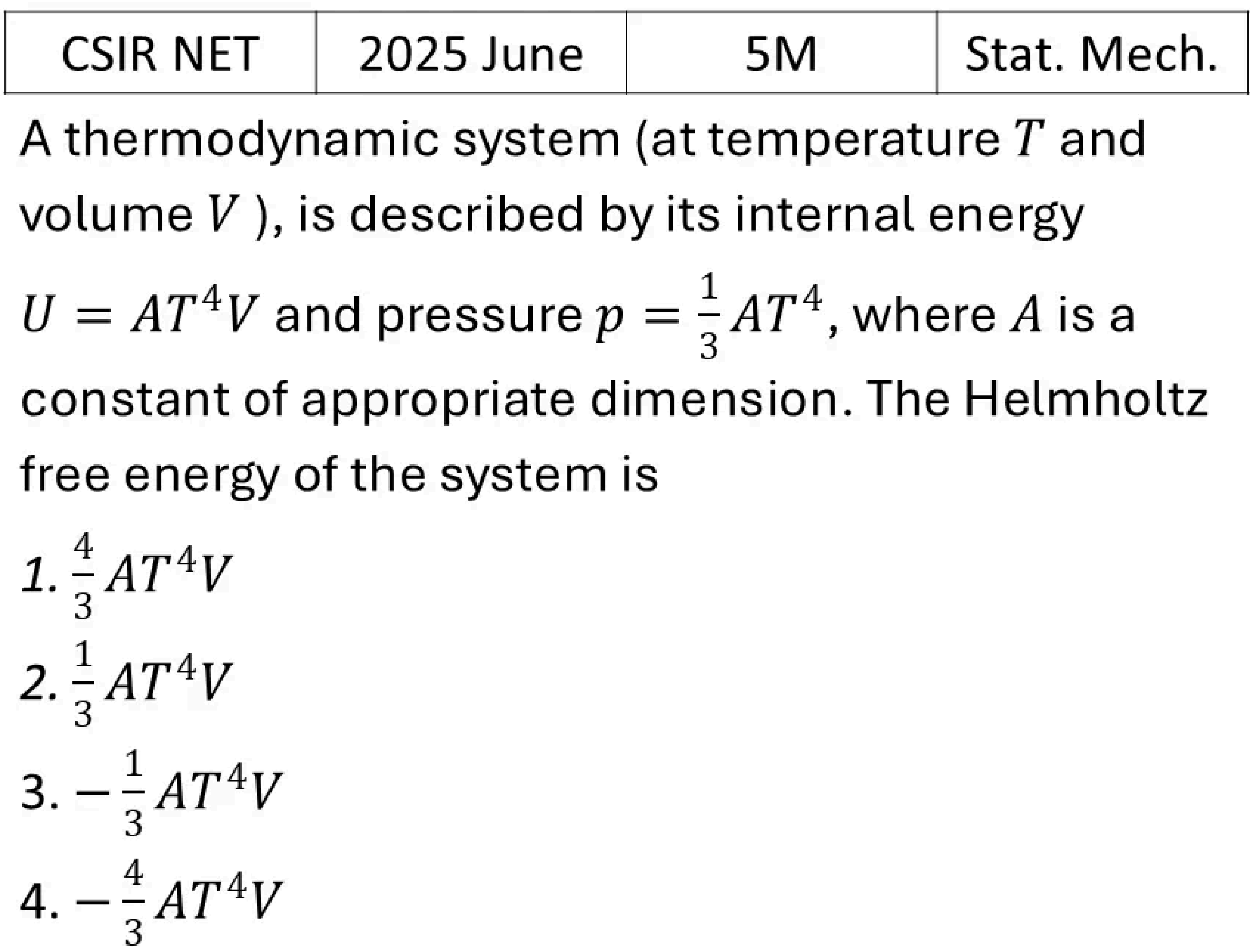
CSIR NET	2025 June	5M	Stat. Mech.

A rigid molecule can have two possible rotational states: $j = 0$ or $j = 1$. Its rotational energies are given by $\epsilon_J = \frac{\hbar^2}{2I} j(j+1)$, where I is its moment of inertia. For an ensemble of such molecules in thermal equilibrium at temperature T, the ratio of the number of molecules in the $j = 1$ state (N_1), to those in $j = 0$ state (N_0), is $\frac{N_1}{N_0} = 0.003$. The temperature T (in units of $\frac{\hbar^2}{2Ik_B}$, where k_B is the Boltzmann constant) is closest to

1. 0.29 2. 0.21 3. 0.15 4. 0.34

Q36. [June 2025] . 5.0 marks

Statistical Mechanics > Canonical Ensemble



CSIR NET	2025 June	5M	Stat. Mech.

A thermodynamic system (at temperature T and volume V), is described by its internal energy $U = AT^4V$ and pressure $p = \frac{1}{3}AT^4$, where A is a constant of appropriate dimension. The Helmholtz free energy of the system is

1. $\frac{4}{3}AT^4V$
2. $\frac{1}{3}AT^4V$
3. $-\frac{1}{3}AT^4V$
4. $-\frac{4}{3}AT^4V$

Answer Key

36 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Statistical Mechanics	Canonical Ensemble	**1**
Q2	Statistical Mechanics	Canonical Ensemble	**4**
Q3	Statistical Mechanics	Canonical Ensemble	**1**
Q4	Statistical Mechanics	Canonical Ensemble	**4**
Q5	Statistical Mechanics	Canonical Ensemble	**2**
Q6	Statistical Mechanics	Canonical Ensemble	**3**
Q7	Statistical Mechanics	Canonical Ensemble	**3**
Q8	Statistical Mechanics	Canonical Ensemble	**3**
Q9	Statistical Mechanics	Canonical Ensemble	**1**
Q10	Statistical Mechanics	Canonical Ensemble	**1**
Q11	Statistical Mechanics	Canonical Ensemble	**4**
Q12	Statistical Mechanics	Canonical Ensemble	**1**
Q13	Statistical Mechanics	Canonical Ensemble	**4**
Q14	Statistical Mechanics	Canonical Ensemble	**4**
Q15	Statistical Mechanics	Canonical Ensemble	**2**
Q16	Statistical Mechanics	Canonical Ensemble	**4**
Q17	Statistical Mechanics	Canonical Ensemble	**1**
Q18	Statistical Mechanics	Canonical Ensemble	**4**
Q19	Statistical Mechanics	Canonical Ensemble	**2**
Q20	Statistical Mechanics	Canonical Ensemble	**3**
Q21	Statistical Mechanics	Canonical Ensemble	**4**
Q22	Statistical Mechanics	Canonical Ensemble	**2**
Q23	Statistical Mechanics	Canonical Ensemble	**4**
Q24	Statistical Mechanics	Canonical Ensemble	**4**
Q25	Statistical Mechanics	Canonical Ensemble	**3**
Q26	Statistical Mechanics	Canonical Ensemble	**2**
Q27	Statistical Mechanics	Canonical Ensemble	**4**
Q28	Statistical Mechanics	Canonical Ensemble	**2**
Q29	Statistical Mechanics	Canonical Ensemble	**2**
Q30	Statistical Mechanics	Canonical Ensemble	**4**
Q31	Statistical Mechanics	Canonical Ensemble	**1**
Q32	Statistical Mechanics	Canonical Ensemble	**2**
Q33	Statistical Mechanics	Canonical Ensemble	**4**
Q34	Statistical Mechanics	Canonical Ensemble	**1**
Q35	Statistical Mechanics	Canonical Ensemble	**1**
Q36	Statistical Mechanics	Canonical Ensemble	**3**