PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Ising model - CSIR NET Physics PYQs

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

11 questions . Answer key included

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Q1. [Dec 2015] . 3.5 marks

Statistical Mechanics > Ising model

CSIR NET	2015 Dec	3.5 M

The partition function of a system of N Ising spins is $Z = \lambda_1^N + \lambda_2^N$ where λ_1 and λ_2 are functions of temperature, but are independent of N. If $\lambda_1 > \lambda_2$, the free energy per spin in the limit $N \to \infty$ is

1. $-k_B T \ln\left(\frac{\lambda_1}{\lambda_2}\right)$
2. $-k_B T \ln \lambda_2$
3. $-k_B T \ln(\lambda_1 \lambda_2)$
4. $-k_B T \ln \lambda_1$

Q2. [June 2015] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2015 June	5 M

Consider three Ising spins at the vertices of a triangle which interact with each other with a ferromagnetic Ising interaction of strength J. The partition function of the system at temperature T is given by

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

1. $2e^{3\beta j} + 6e^{-\beta j}$
2. $2e^{-3\beta I} + 6e^{\beta J}$
3. $2e^{3\beta J} + 6e^{-3\beta J} + 3e^{\beta J} + 3e^{-\beta J}$
4. $(2\cosh \beta J)^3$

Q3. [June 2017] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2017 June	5M

The Hamiltonian for three Ising spins S_0, S_1 and S_2, taking values ± 1, is $H = -JS_0(S_1 + S_2)$

If the system is in equilibrium at temperature T, the average energy of the system, in terms of $\beta = (k_B T)^{-1}$, is

1. $-\frac{1+\cosh(2\beta J)}{2\beta \sinh(2\beta J)}$
2. $-2J[1 + cos\, h(2\beta J)]$
3. $-2/\beta$
4. $-2J\frac{\sinh(2\beta J)}{1+\cosh(2\beta J)}$

Q4. [Dec 2018] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2018 Dec	5M

The Hamiltonian of a one-dimensional Ising model of N spins (N large) is

$$H = -J \sum_{i=1}^{N} \sigma_i \sigma_{i+1}$$

where the spin $\sigma_i = \pm 1$ and J is a positive constant. At inverse temperature $\beta = \frac{1}{k_B T}$, the correlation function between the nearest neighbor spins ($\sigma_i \sigma_{i+1}$) is

1. $\frac{e^{-\beta J}}{(e^{\beta J} + e^{-\beta J})}$
2. $e^{-2\beta J}$
3. $tanh(\beta J)$
4. $\coth(\beta J)$

Q5. [June 2019] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2019 June	5M

The Hamiltonian of three Ising spins S_1, S_2 and S_3, each taking values ± 1, is

$H = -J(S_1S_2 + S_2S_3) - hS_1$, where J and h are positive constants. The mean value of S_3 in equilibrium at a temperature $T = 1/(k_B\beta)$, is

1. $\tanh^3(\beta J)$
2. $\tan(\beta h)\tanh^2(\beta J)$
3. $\sinh(\beta h)\sinh^2(\beta J)$
4. 0

Q6. [June 2020] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2020 June	5M

The Hamiltonian of a system of 3 spins is $H = J(S_1S_2 + S_2S_3)$, where $S_i = \pm 1$ for $i = 1,2,3$. Its canonical partition function, at temperature T, is

1. $2\left(2\sinh\frac{J}{k_BT}\right)^2$
2. $2\left(2\cosh\frac{J}{k_BT}\right)^2$
3. $2\left(2\cosh\frac{J}{k_BT}\right)$
4. $2\left(2\cosh\frac{J}{k_BT}\right)^3$

Q7. [June 2023] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2023 June	5M

In a one-dimensional system of N spins, the allowed values of each spin are $\sigma_i = \{1,2,3,\ldots,q\}$, where $q \geq 2$ is an integer. The energy of the system is $-J\sum_{i=1}^{N} \delta_{\sigma_i,\sigma_{i+1}}$ where $J > 0$ is a constant. If periodic boundary conditions are imposed, the number of ground states of the system is

1. q
2. Nq
3. q^N
4. 1

Q8. [Dec 2024] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2024 Dec	5M

Energy of two Ising spins $\left(s = \pm\frac{1}{2}\right)$ is given by

$$E = s_1 s_2 + s_1 + s_2.$$

At temperature T, the probability that both spins take the value $-\frac{1}{2}$ is 16 times the probability that both take the value $+\frac{1}{2}$. At the same temperature, what is the probability that the spins take opposite values?

1. $\frac{16}{25}$
2. $\frac{8}{25}$
3. $\frac{8}{33}$
4. $\frac{16}{33}$

Q9. [June 2024] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2024 June	5M

Five classical spins are placed at the vertices of a regular pentagon. The Hamiltonian of the system is $H = J\sum S_i S_j$, where $J > 0, S_i = \pm 1$ and the sum is over all possible nearest neighbour pairs. The degeneracy of the ground state is

1. 8
2. 5
3. 4
4. 10

Q10. [Dec 2025] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2025 Dec	5M	Stat. Mech.

A binary alloy consists of N_A number of A-type and N_B number of B-type atoms. The atoms sit on the sites of a simple cubic lattice and the nearest neighbours interact with each other. Assume an attractive interaction energy $-J(J>0)$ between two like neighbours (AA or BB pair) and a repulsive interaction energy $+J$ between two unlike neighbours (AB pair). If N is the total number of sites, then the average energy of the system at a very high temperature ($k_BT \gg J$) is

1. $-3J\frac{(N_A-N_B)^2}{N}$
2. $3JN$
3. $3j\frac{(N_A+N_B)^2}{N}$
4. $-3J(N_A-N_B)$

Q11. [June 2025] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2025 June	5M	Stat. Mech.

Consider $2N$ Ising spins, $s_i (s_i = \pm 1)$ in a one-dimensional lattice with periodic boundary conditions. The Hamiltonian is given by

$$H = -J \sum_{i=1}^{2N} s_i s_{i+1}$$

where J denotes the strength of the nearest-neighbour interactions with $J > 0$. Let F be the fully ferromagnetic state and let A be the lowest energy state with zero magnetization. The energy difference between these two states is

1. $\frac{3J}{2}$ 2. 4J 3. $\frac{J}{2}$ 4. $2J$

Answer Key

11 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Statistical Mechanics	Ising model	**4**
Q2	Statistical Mechanics	Ising model	**1**
Q3	Statistical Mechanics	Ising model	**4**
Q4	Statistical Mechanics	Ising model	**3**
Q5	Statistical Mechanics	Ising model	**2**
Q6	Statistical Mechanics	Ising model	**2**
Q7	Statistical Mechanics	Ising model	**1**
Q8	Statistical Mechanics	Ising model	**4**
Q9	Statistical Mechanics	Ising model	**4**
Q10	Statistical Mechanics	Ising model	**1**
Q11	Statistical Mechanics	Ising model	**2**

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