PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - Thermodynamics

All PYQs (2015-2025) with answer key

32 questions . Answer key included

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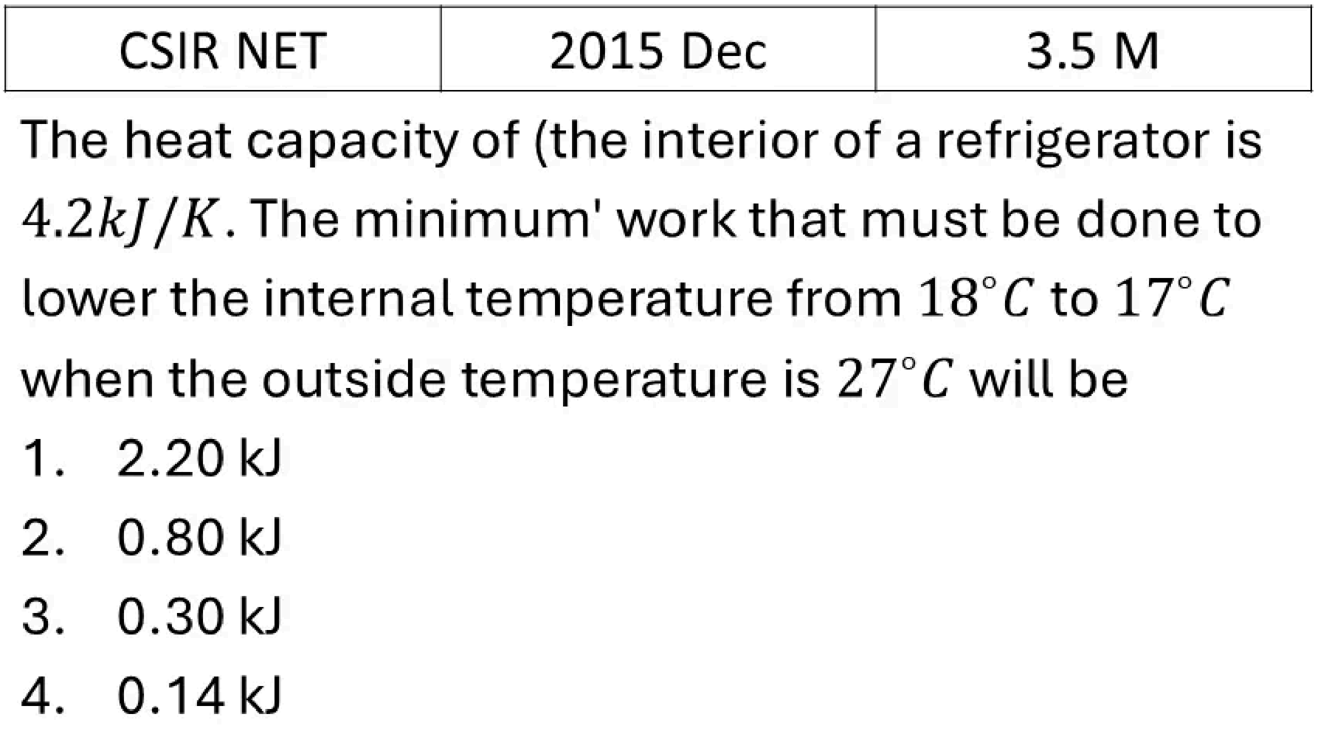
Q1. [Dec 2015] . 3.5 marks

Thermodynamics > Carnot Cycle



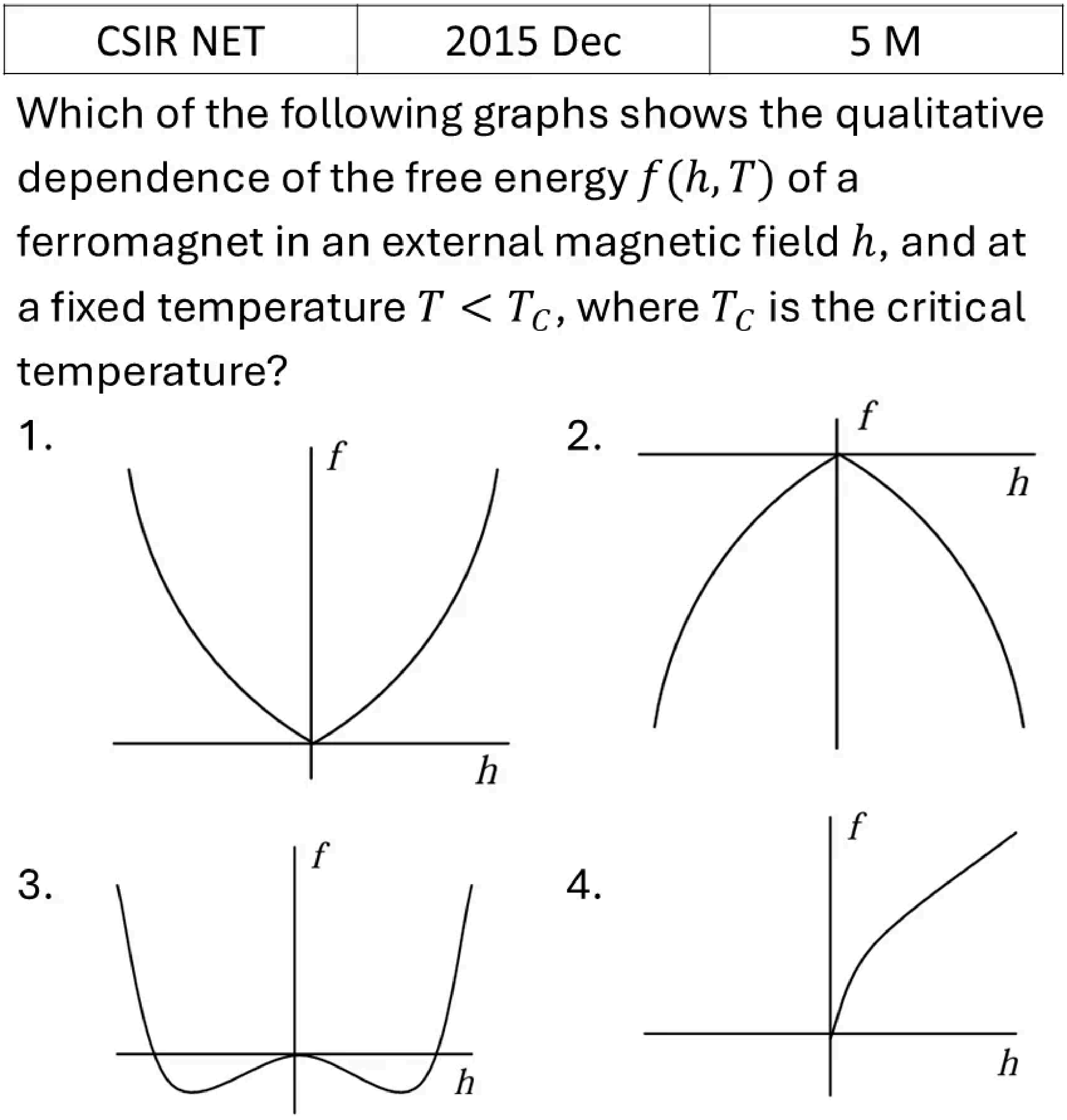
CSIR NET	2015 Dec	3.5 M

The heat capacity of (the interior of a refrigerator is $4.2kJ/K$. The minimum' work that must be done to lower the internal temperature from $18^\circ C$ to $17^\circ C$ when the outside temperature is $27^\circ C$ will be

1. 2.20 kJ
2. 0.80 kJ
3. 0.30 kJ
4. 0.14 kJ

Q2. [Dec 2015] . 5.0 marks

Thermodynamics > Phase transitions



CSIR NET	2015 Dec	5 M

Which of the following graphs shows the qualitative dependence of the free energy $f(h,T)$ of a ferromagnet in an external magnetic field h, and at a fixed temperature $T < T_C$, where T_C is the critical temperature?

1.

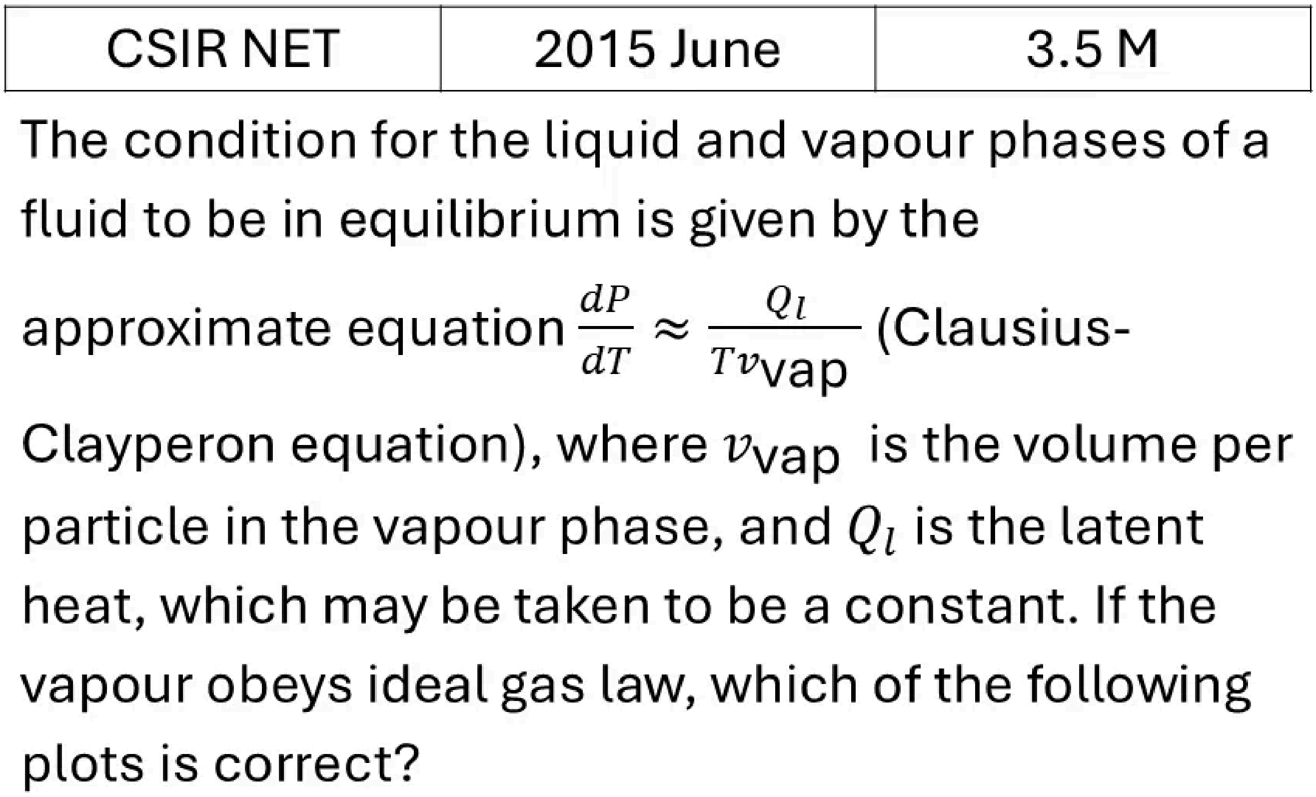
2.

3.

4.

Q3. [June 2015] . 3.5 marks

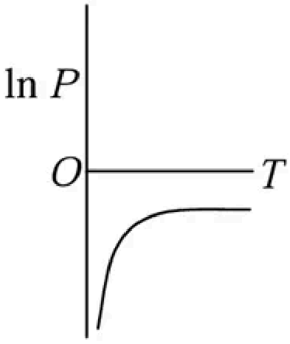
Thermodynamics > Phase transitions



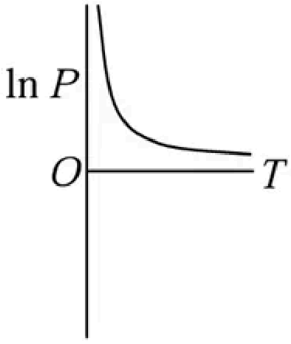
CSIR NET	2015 June	3.5 M

The condition for the liquid and vapour phases of a fluid to be in equilibrium is given by the approximate equation $\frac{dP}{dT} \approx \frac{Q_l}{T v_{\text{vap}}}$ (Clausius-Clayperon equation), where v_{vap} is the volume per particle in the vapour phase, and Q_l is the latent heat, which may be taken to be a constant. If the vapour obeys ideal gas law, which of the following plots is correct?

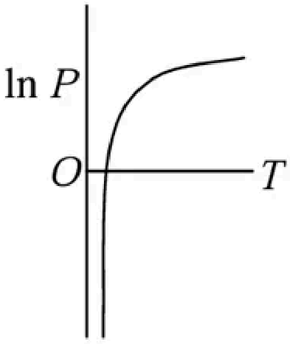
(a)



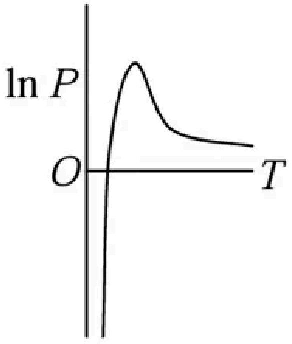
(b)



(c)

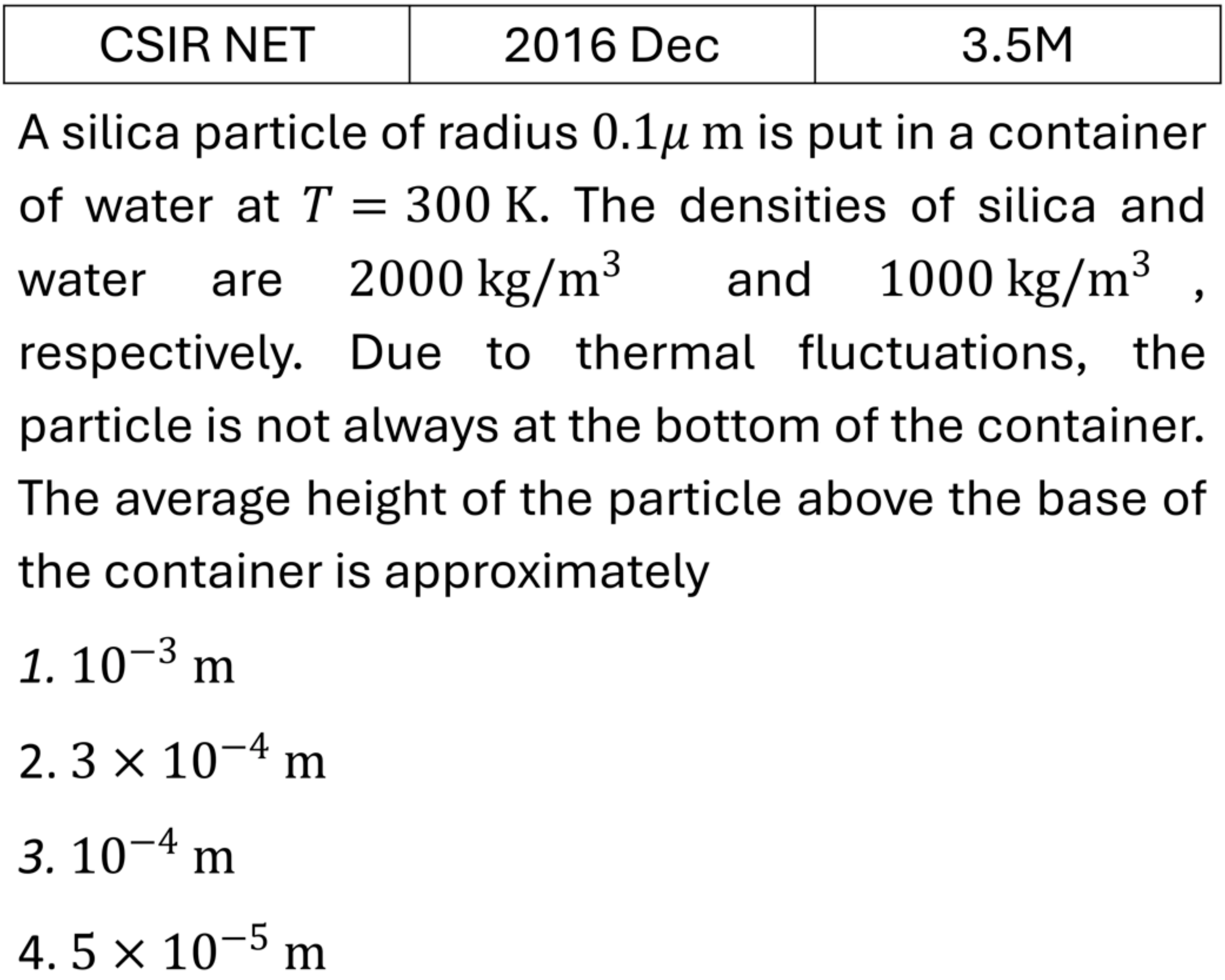


(d)



Q4. [Dec 2016] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



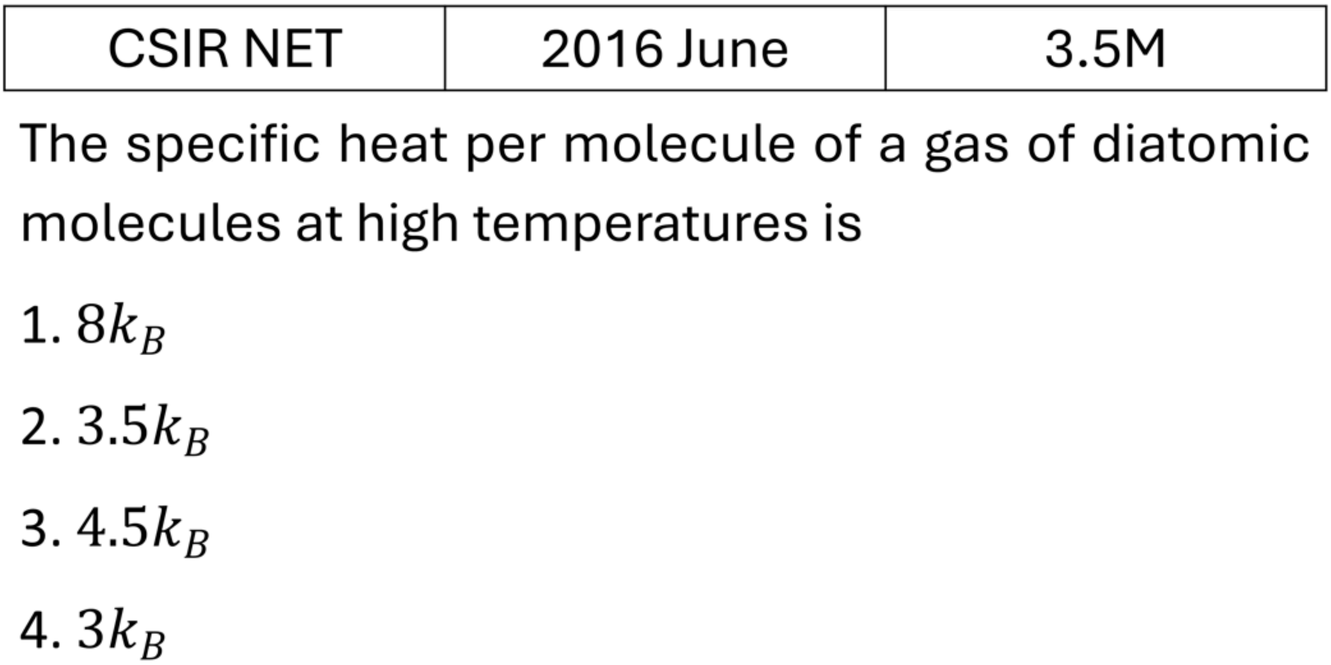
CSIR NET	2016 Dec	3.5M

A silica particle of radius $0.1\mu\,\mathrm{m}$ is put in a container of water at $T = 300\,\mathrm{K}$. The densities of silica and water are $2000\,\mathrm{kg/m^3}$ and $1000\,\mathrm{kg/m^3}$, respectively. Due to thermal fluctuations, the particle is not always at the bottom of the container. The average height of the particle above the base of the container is approximately

1. $10^{-3}\,\mathrm{m}$
2. $3 \times 10^{-4}\,\mathrm{m}$
3. $10^{-4}\,\mathrm{m}$
4. $5 \times 10^{-5}\,\mathrm{m}$

Q5. [June 2016] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



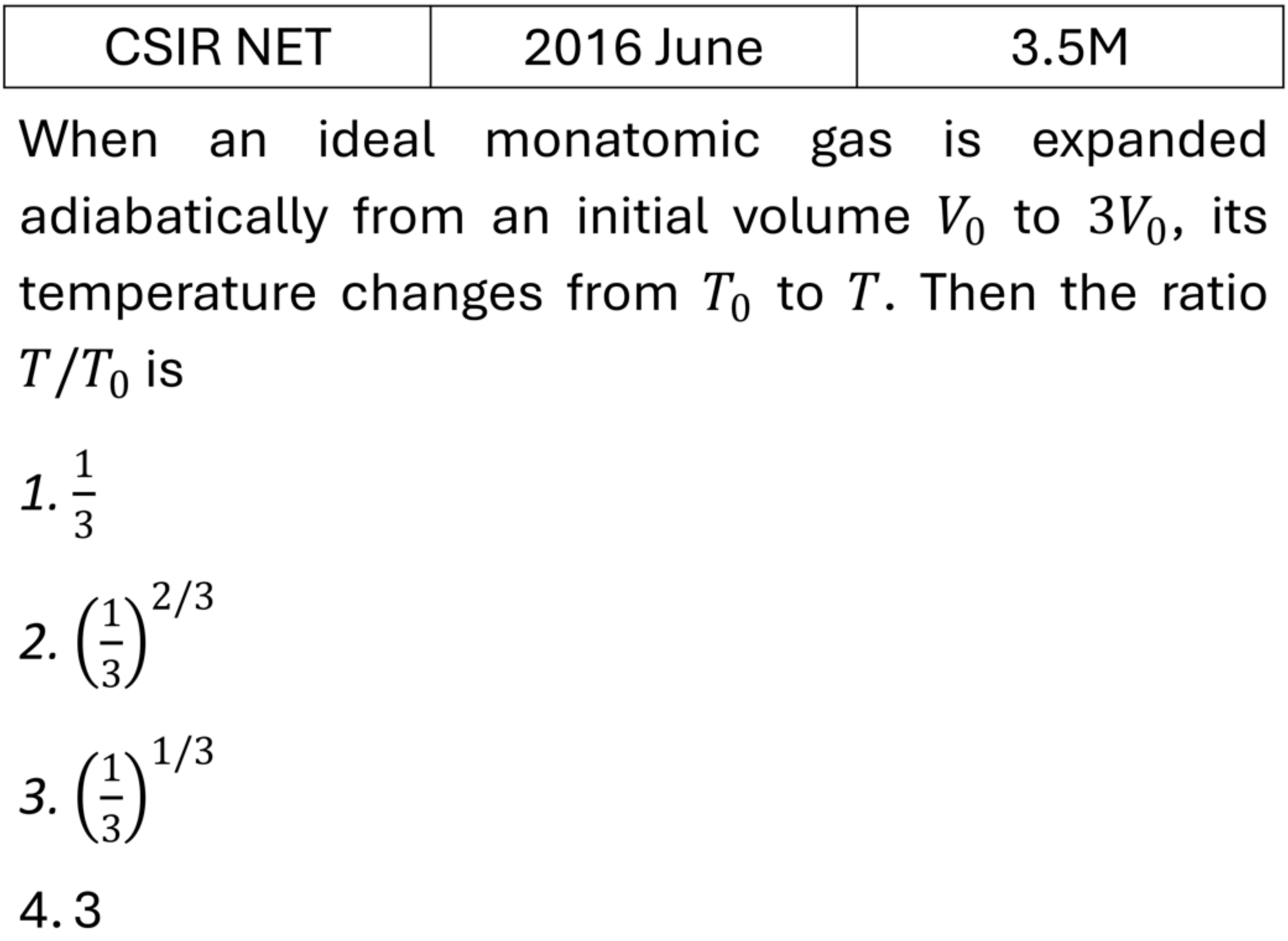
CSIR NET	2016 June	3.5M

The specific heat per molecule of a gas of diatomic molecules at high temperatures is

1. $8k_B$
2. $3.5k_B$
3. $4.5k_B$
4. $3k_B$

Q6. [June 2016] . 3.5 marks

Thermodynamics > Laws of thermodynamics



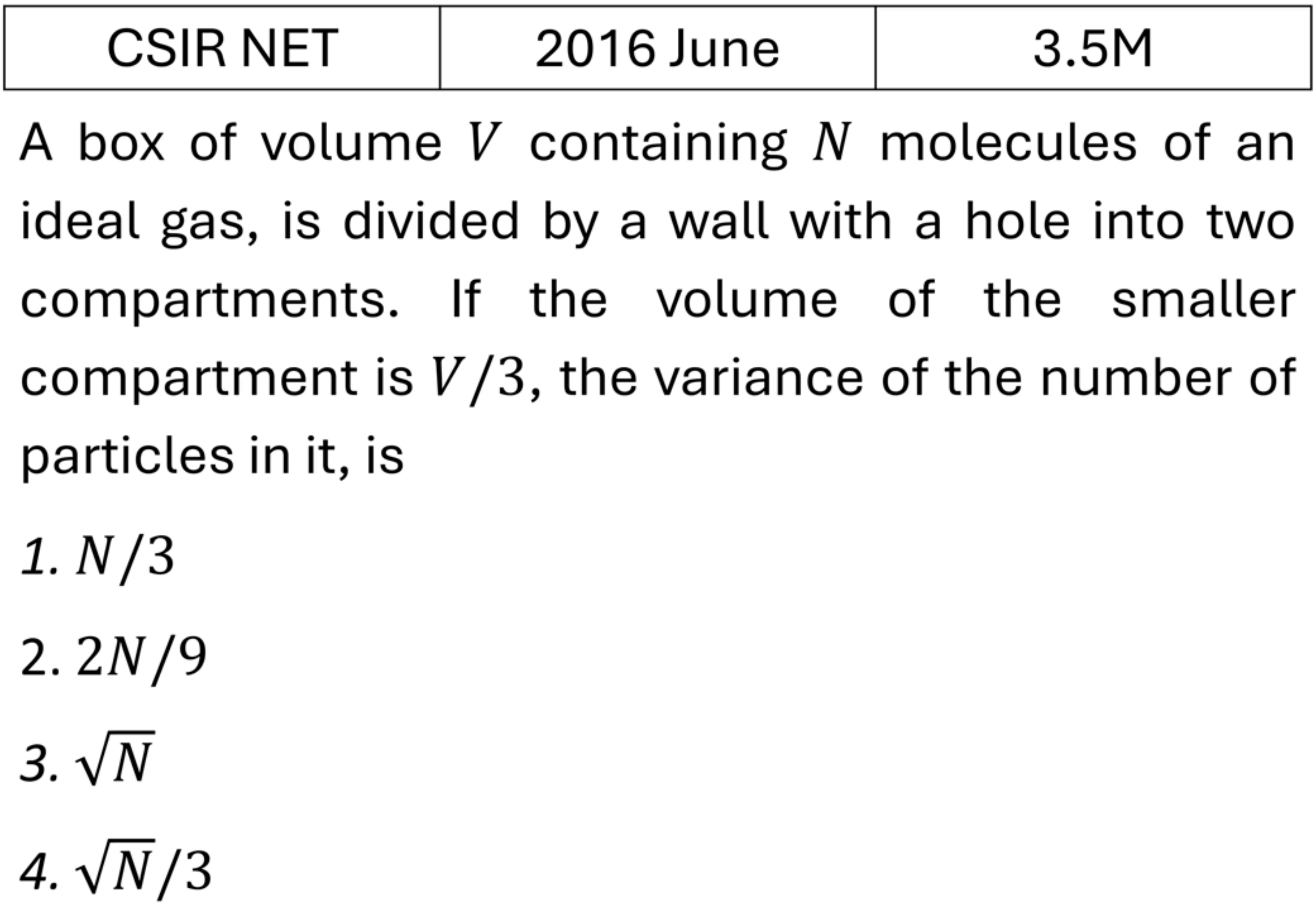
CSIR NET	2016 June	3.5M

When an ideal monatomic gas is expanded adiabatically from an initial volume V_0 to $3V_0$, its temperature changes from T_0 to T. Then the ratio T/T_0 is

1. $\frac{1}{3}$
2. $\left(\frac{1}{3}\right)^{2/3}$
3. $\left(\frac{1}{3}\right)^{1/3}$
4. 3

Q7. [June 2016] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



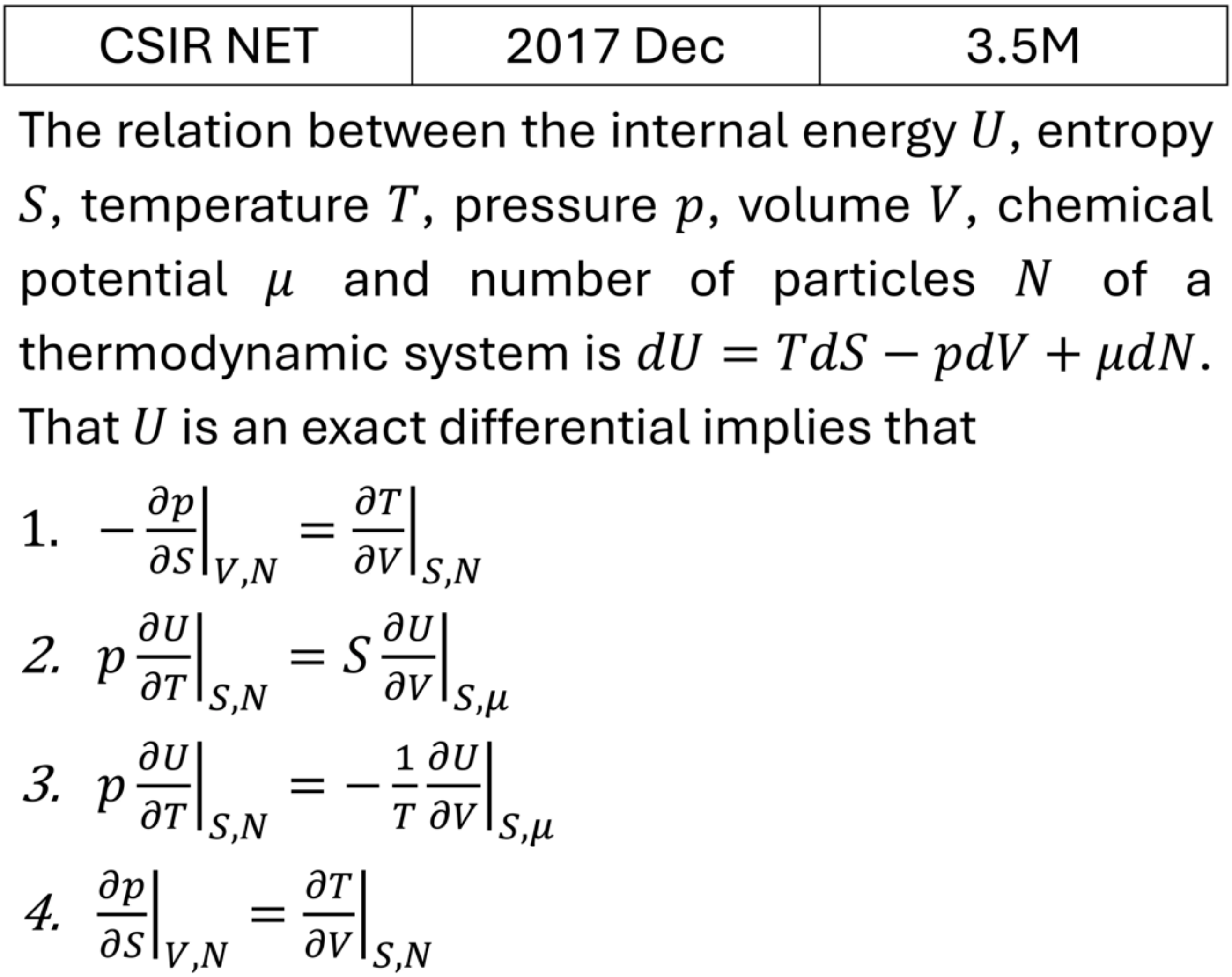
CSIR NET	2016 June	3.5M

A box of volume V containing N molecules of an ideal gas, is divided by a wall with a hole into two compartments. If the volume of the smaller compartment is $V/3$, the variance of the number of particles in it, is

1. $N/3$
2. $2N/9$
3. $\sqrt{N}$
4. $\sqrt{N}/3$

Q8. [Dec 2017] . 3.5 marks

Thermodynamics > Thermodynamic relations and maxwell equations



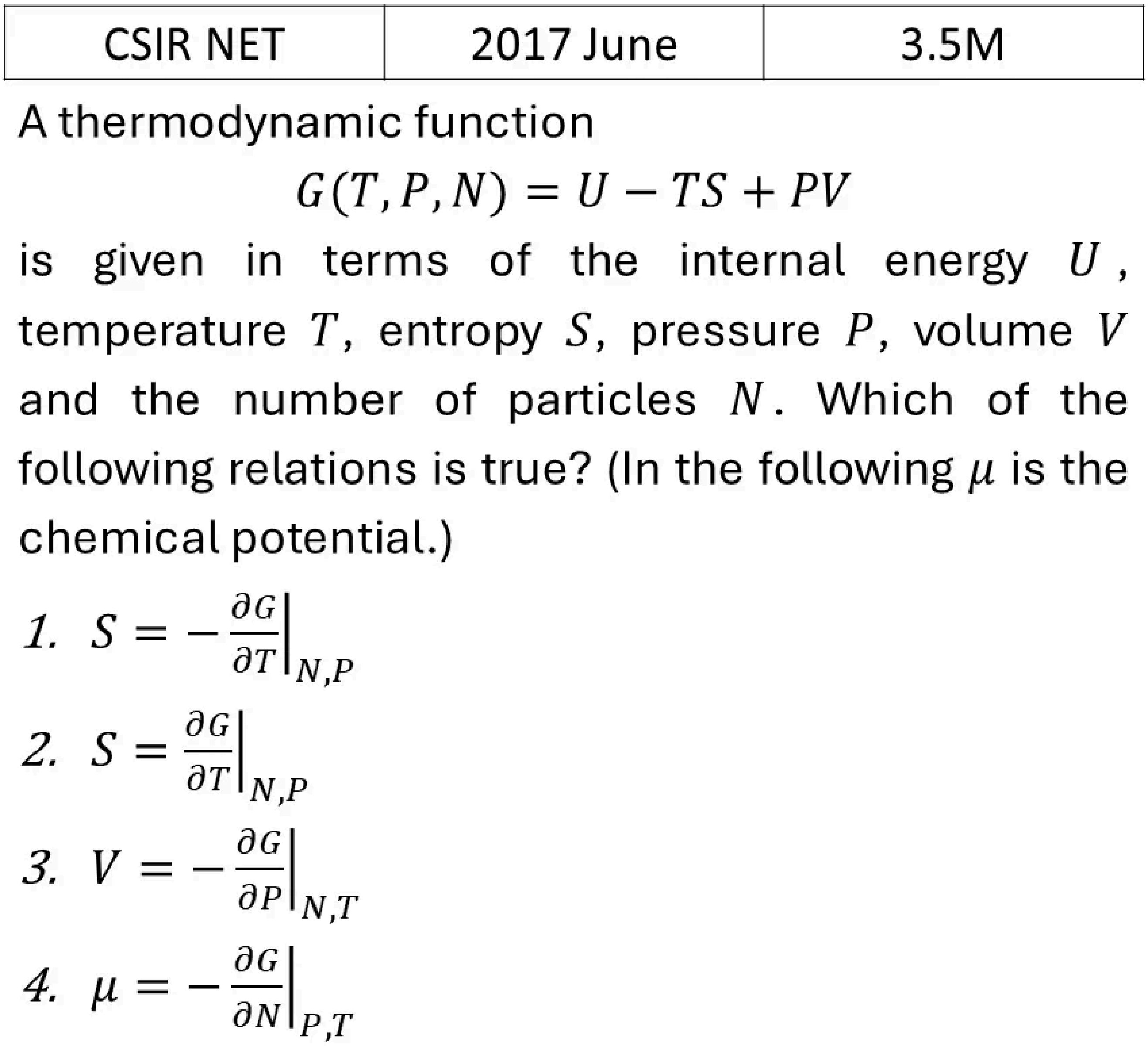
CSIR NET	2017 Dec	3.5M

The relation between the internal energy U, entropy S, temperature T, pressure p, volume V, chemical potential μ and number of particles N of a thermodynamic system is $dU = TdS - pdV + \mu dN$. That U is an exact differential implies that

1. $-\left.\frac{\partial p}{\partial S}\right|_{V,N} = \left.\frac{\partial T}{\partial V}\right|_{S,N}$
2. $p\left.\frac{\partial U}{\partial T}\right|_{S,N} = S\left.\frac{\partial U}{\partial V}\right|_{S,\mu}$
3. $p\left.\frac{\partial U}{\partial T}\right|_{S,N} = -\frac{1}{T}\left.\frac{\partial U}{\partial V}\right|_{S,\mu}$
4. $\left.\frac{\partial p}{\partial S}\right|_{V,N} = \left.\frac{\partial T}{\partial V}\right|_{S,N}$

Q9. [June 2017] . 3.5 marks

Thermodynamics > Thermodynamic relations and maxwell equations



CSIR NET	2017 June	3.5M

A thermodynamic function

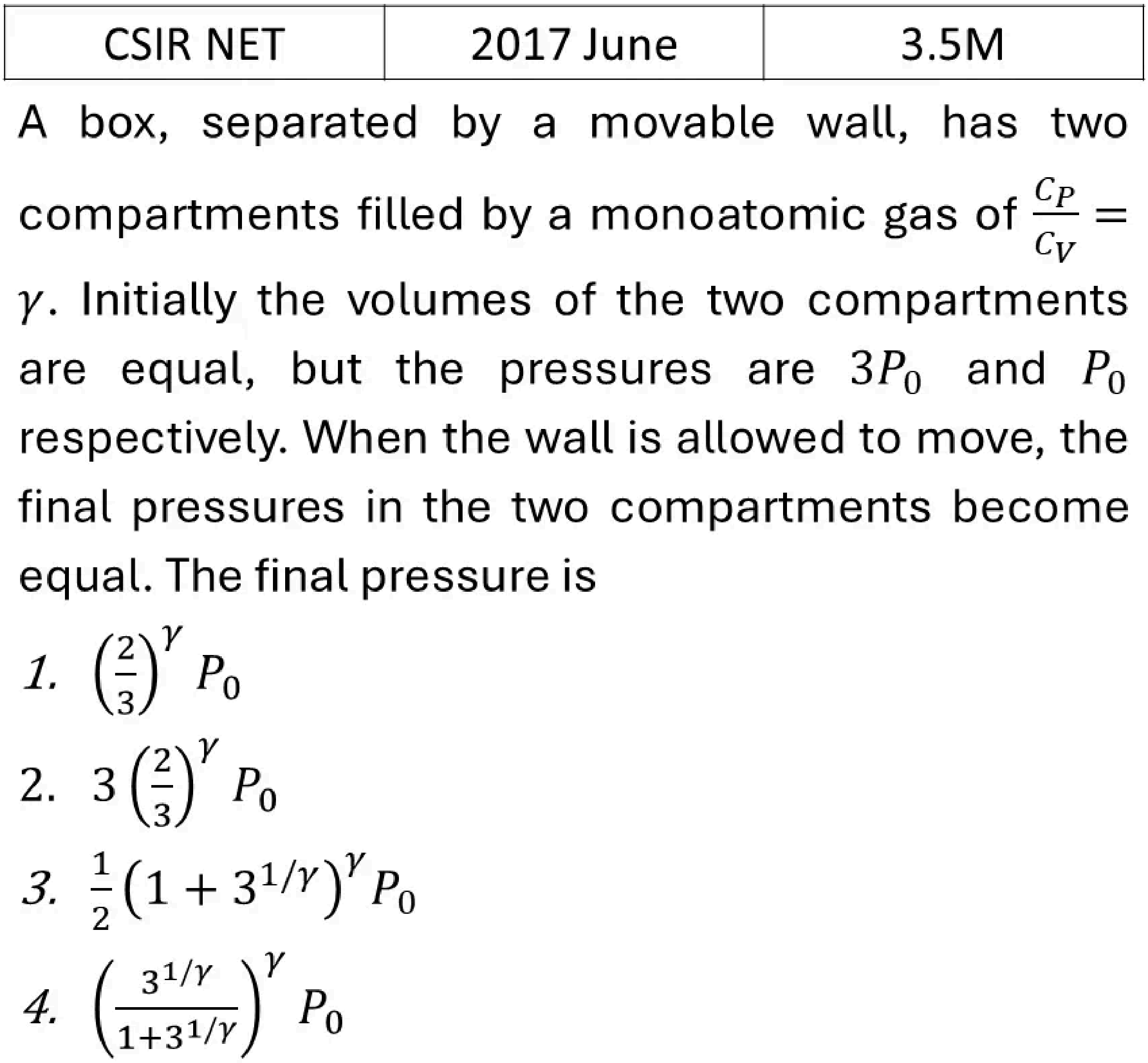
$$G(T,P,N) = U - TS + PV$$

is given in terms of the internal energy U, temperature T, entropy S, pressure P, volume V and the number of particles N. Which of the following relations is true? (In the following μ is the chemical potential.)

1. $S = -\left.\frac{\partial G}{\partial T}\right|_{N,P}$
2. $S = \left.\frac{\partial G}{\partial T}\right|_{N,P}$
3. $V = -\left.\frac{\partial G}{\partial P}\right|_{N,T}$
4. $\mu = -\left.\frac{\partial G}{\partial N}\right|_{P,T}$

Q10. [June 2017] . 3.5 marks

Thermodynamics > Laws of thermodynamics



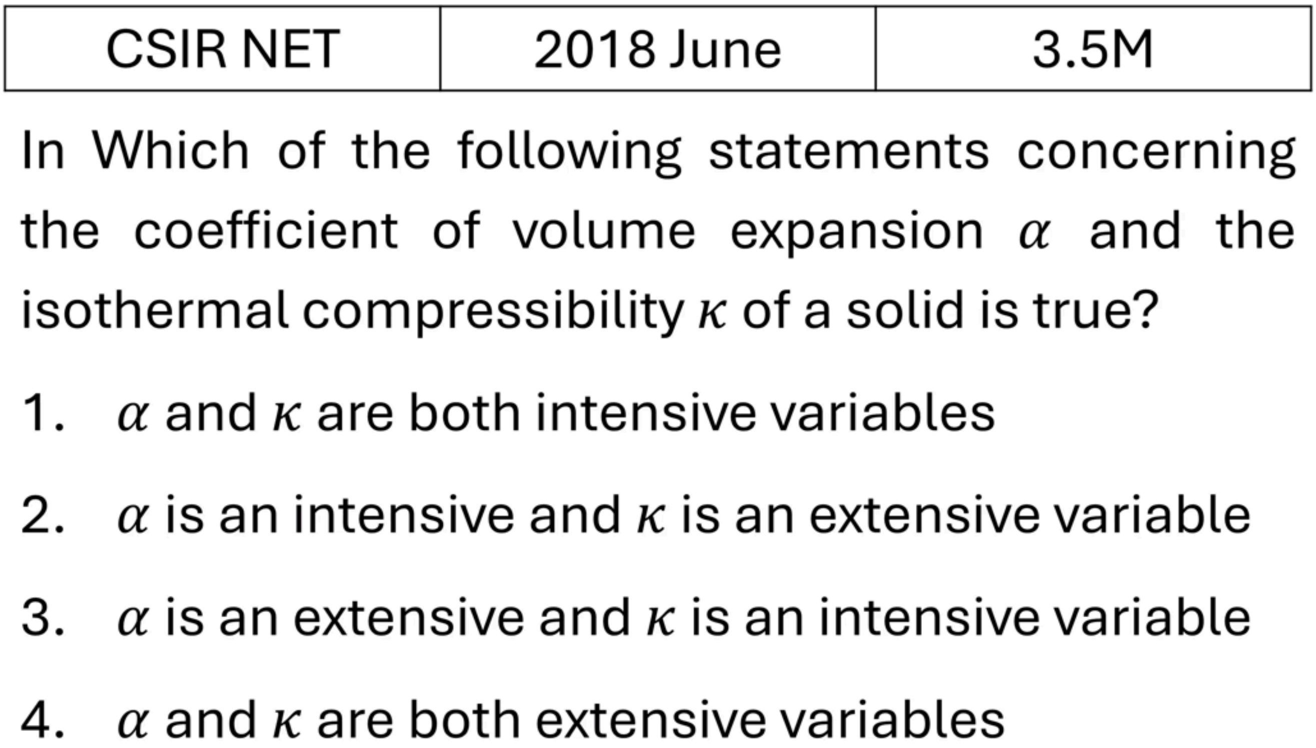
CSIR NET	2017 June	3.5M

A box, separated by a movable wall, has two compartments filled by a monoatomic gas of $\frac{C_P}{C_V} = \gamma$. Initially the volumes of the two compartments are equal, but the pressures are $3P_0$ and P_0 respectively. When the wall is allowed to move, the final pressures in the two compartments become equal. The final pressure is

1. $\left(\frac{2}{3}\right)^{\gamma} P_0$
2. $3\left(\frac{2}{3}\right)^{\gamma} P_0$
3. $\frac{1}{2}\left(1 + 3^{1/\gamma}\right)^{\gamma} P_0$
4. $\left(\frac{3^{1/\gamma}}{1+3^{1/\gamma}}\right)^{\gamma} P_0$

Q11. [June 2018] . 3.5 marks

Thermodynamics > Thermodynamic relations and maxwell equations



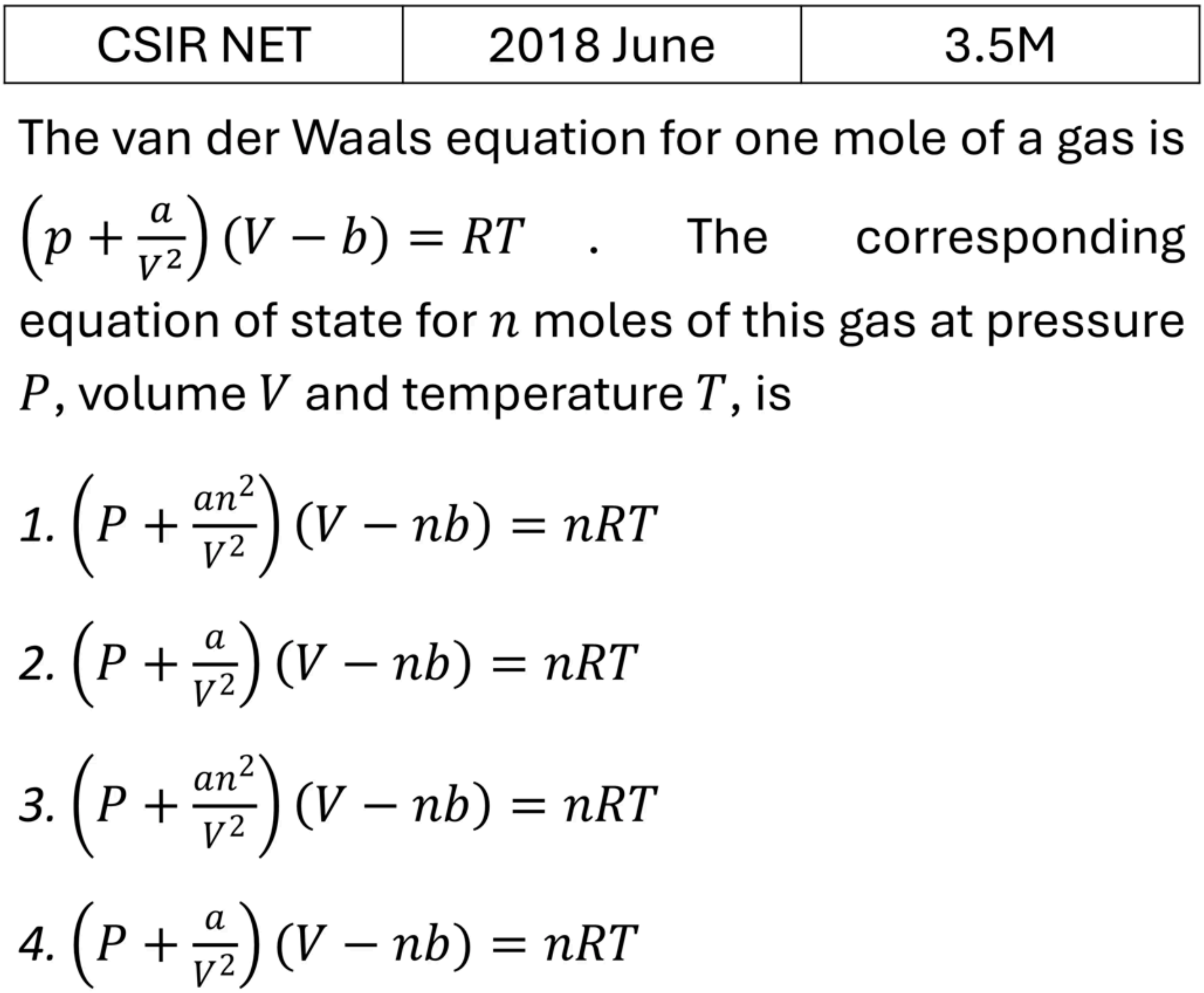
CSIR NET	2018 June	3.5M

In Which of the following statements concerning the coefficient of volume expansion α and the isothermal compressibility κ of a solid is true?

1. α and κ are both intensive variables
2. α is an intensive and κ is an extensive variable
3. α is an extensive and κ is an intensive variable
4. α and κ are both extensive variables

Q12. [June 2018] . 3.5 marks

Thermodynamics > Laws of thermodynamics



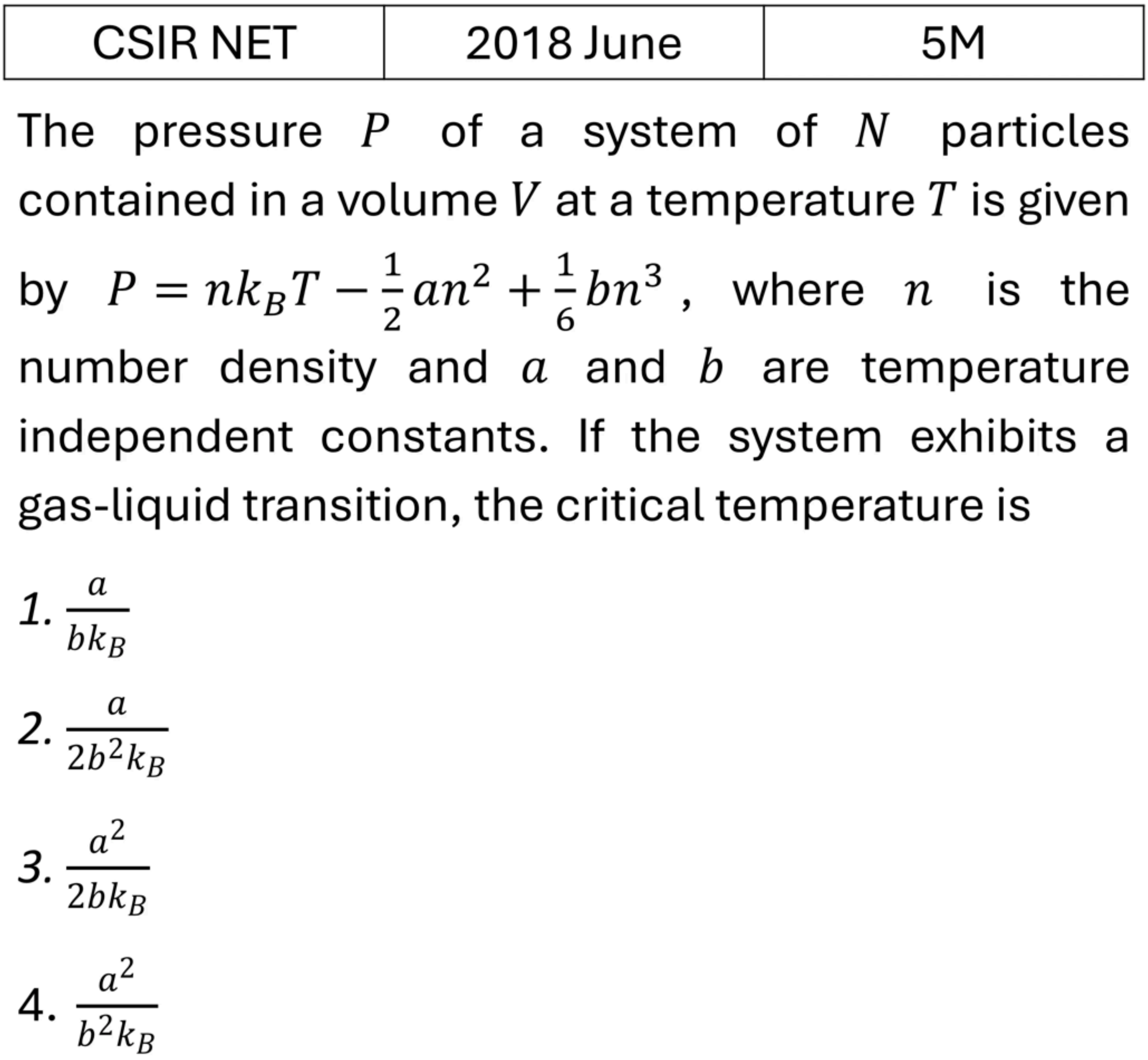
CSIR NET	2018 June	3.5M

The van der Waals equation for one mole of a gas is $\left(p+\frac{a}{V^2}\right)(V-b)=RT$. The corresponding equation of state for n moles of this gas at pressure P, volume V and temperature T, is

1. $\left(P+\frac{an^2}{V^2}\right)(V-nb)=nRT$
2. $\left(P+\frac{a}{V^2}\right)(V-nb)=nRT$
3. $\left(P+\frac{an^2}{V^2}\right)(V-nb)=nRT$
4. $\left(P+\frac{a}{V^2}\right)(V-nb)=nRT$

Q13. [June 2018] . 5.0 marks

Thermodynamics > Phase transitions



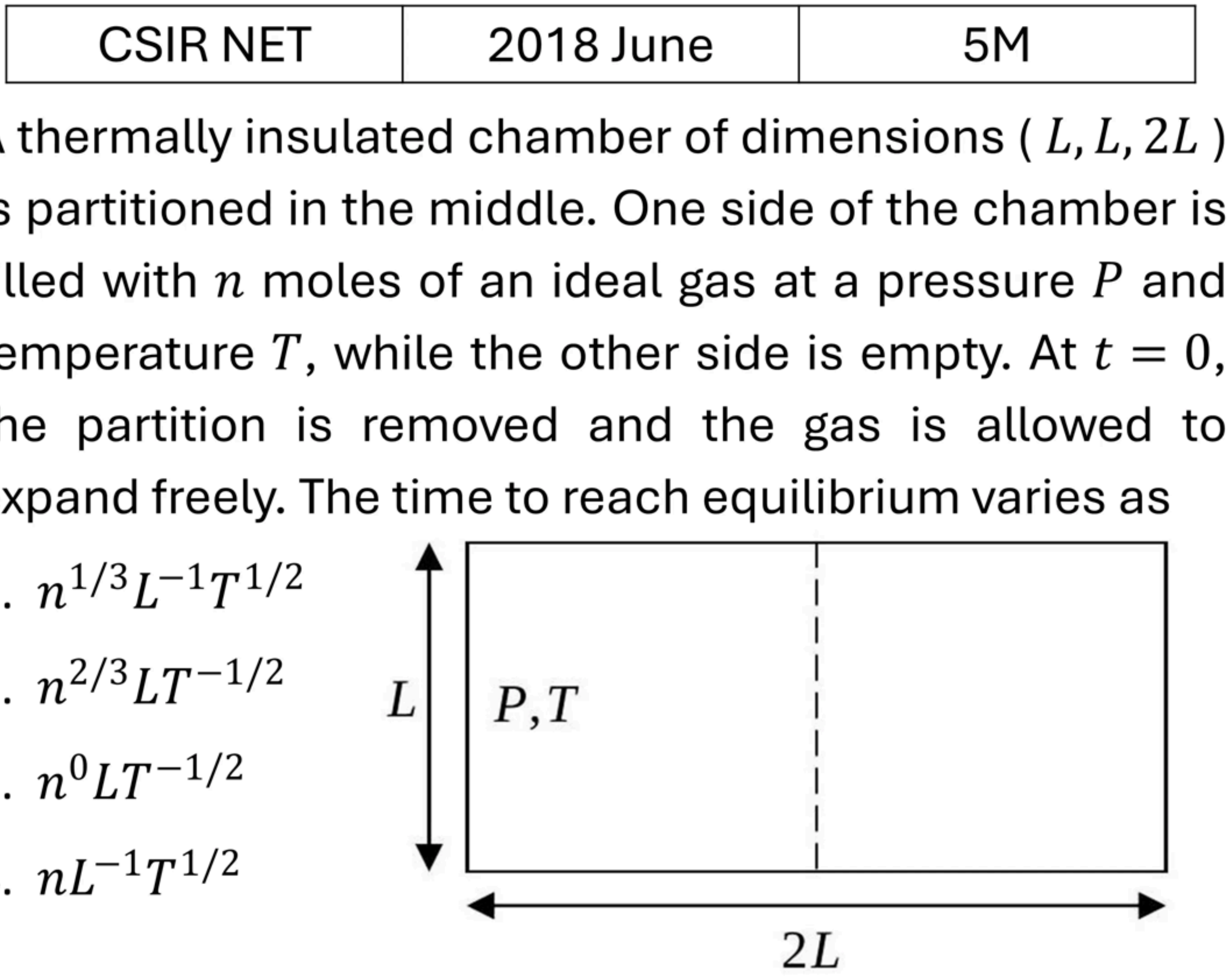
CSIR NET	2018 June	5M

The pressure P of a system of N particles contained in a volume V at a temperature T is given by $P = nk_BT - \frac{1}{2}an^2 + \frac{1}{6}bn^3$, where n is the number density and a and b are temperature independent constants. If the system exhibits a gas-liquid transition, the critical temperature is

1. $\frac{a}{bk_B}$
2. $\frac{a}{2b^2k_B}$
3. $\frac{a^2}{2bk_B}$
4. $\frac{a^2}{b^2k_B}$

Q14. [June 2018] . 5.0 marks

Thermodynamics > Laws of thermodynamics



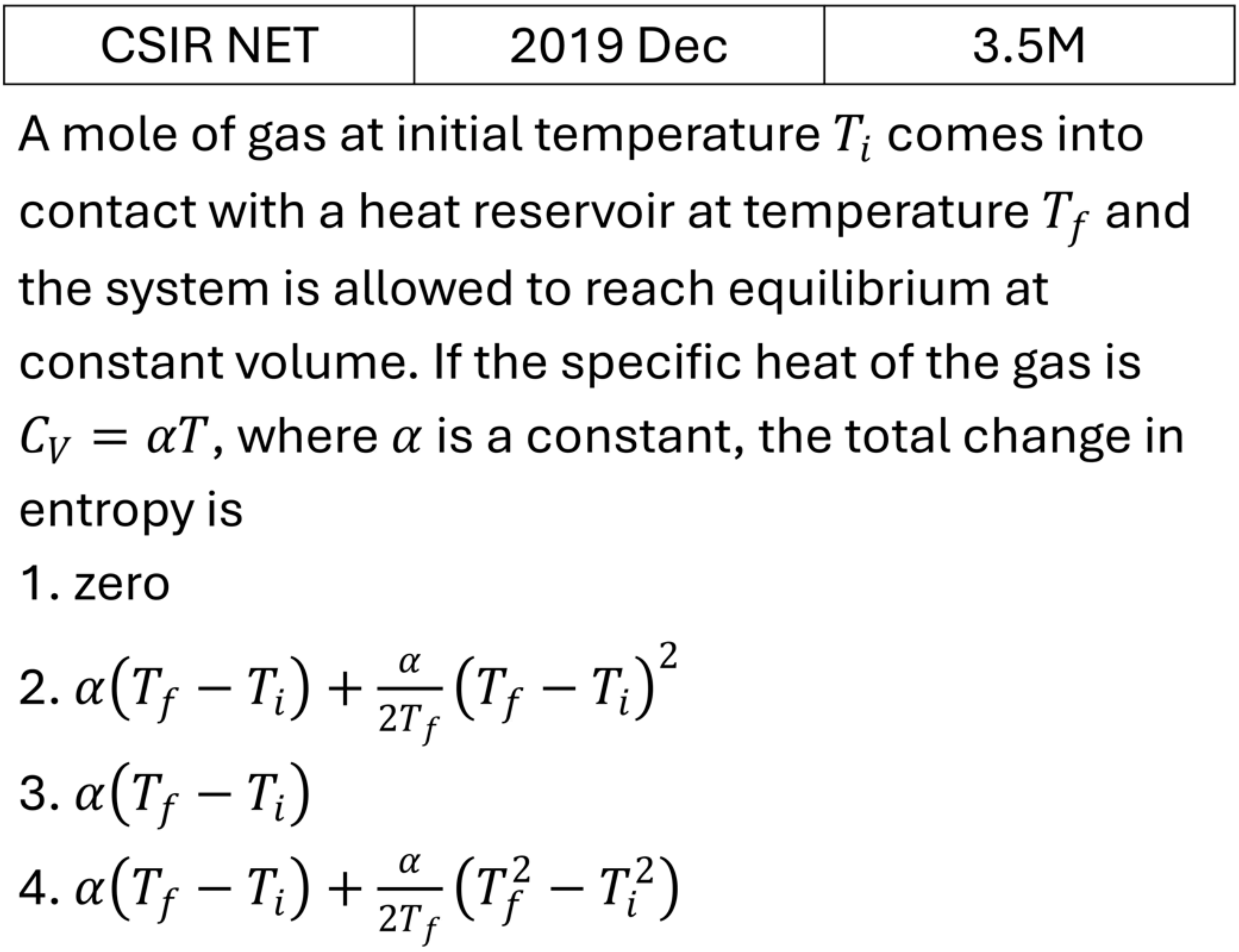
CSIR NET	2018 June	5M

A thermally insulated chamber of dimensions ($L, L, 2L$) is partitioned in the middle. One side of the chamber is filled with n moles of an ideal gas at a pressure P and temperature T, while the other side is empty. At $t = 0$, the partition is removed and the gas is allowed to expand freely. The time to reach equilibrium varies as

1. $n^{1/3}L^{-1}T^{1/2}$
2. $n^{2/3}LT^{-1/2}$
3. $n^{0}LT^{-1/2}$
4. $nL^{-1}T^{1/2}$

Q15. [Dec 2019] . 3.5 marks

Thermodynamics > Laws of thermodynamics



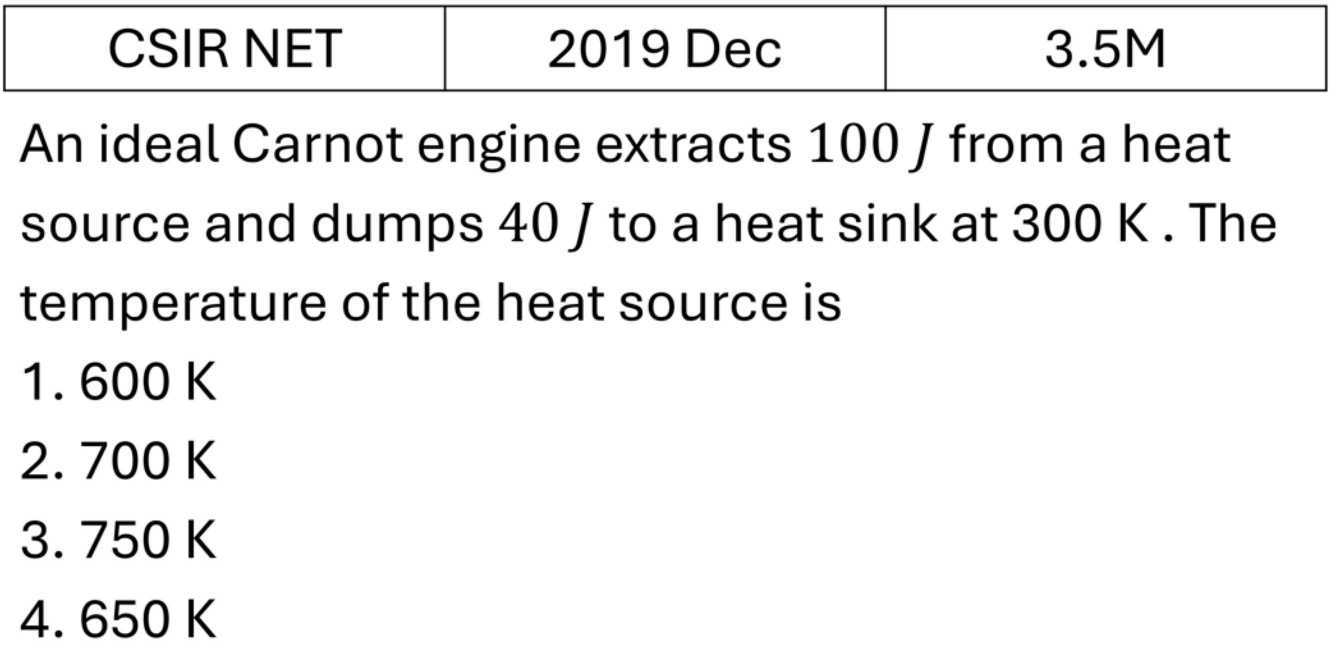
CSIR NET	2019 Dec	3.5M

A mole of gas at initial temperature T_i comes into contact with a heat reservoir at temperature T_f and the system is allowed to reach equilibrium at constant volume. If the specific heat of the gas is $C_V = \alpha T$, where α is a constant, the total change in entropy is

1. zero
2. $\alpha\left(T_f - T_i\right) + \frac{\alpha}{2T_f}\left(T_f - T_i\right)^2$
3. $\alpha\left(T_f - T_i\right)$
4. $\alpha\left(T_f - T_i\right) + \frac{\alpha}{2T_f}\left(T_f^2 - T_i^2\right)$

Q16. [Dec 2019] . 3.5 marks

Thermodynamics > Carnot Cycle



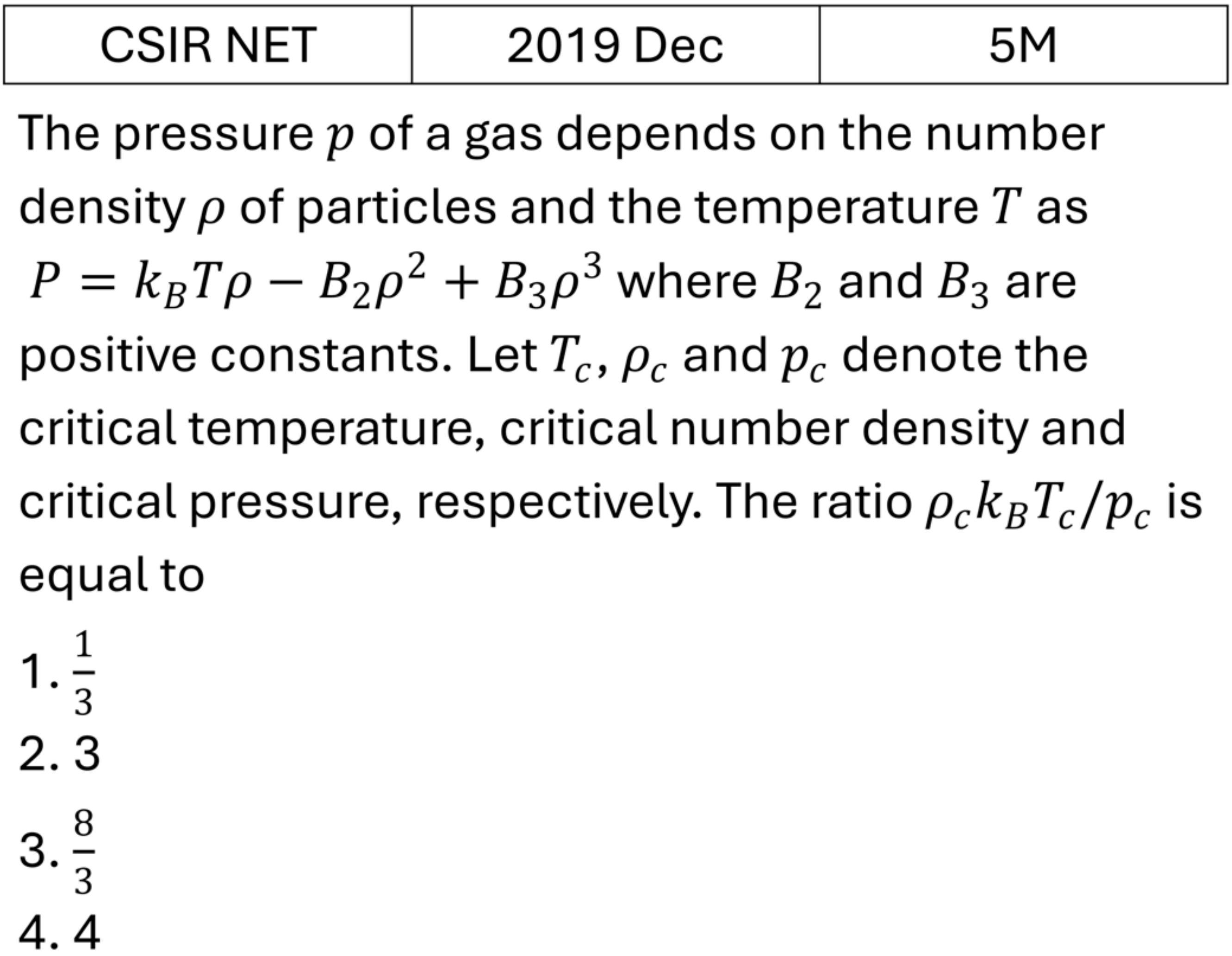
CSIR NET	2019 Dec	3.5M

An ideal Carnot engine extracts 100 J from a heat source and dumps 40 J to a heat sink at 300 K . The temperature of the heat source is

1. 600 K
2. 700 K
3. 750 K
4. 650 K

Q17. [Dec 2019] . 5.0 marks

Thermodynamics > Kinetic theory of Gases



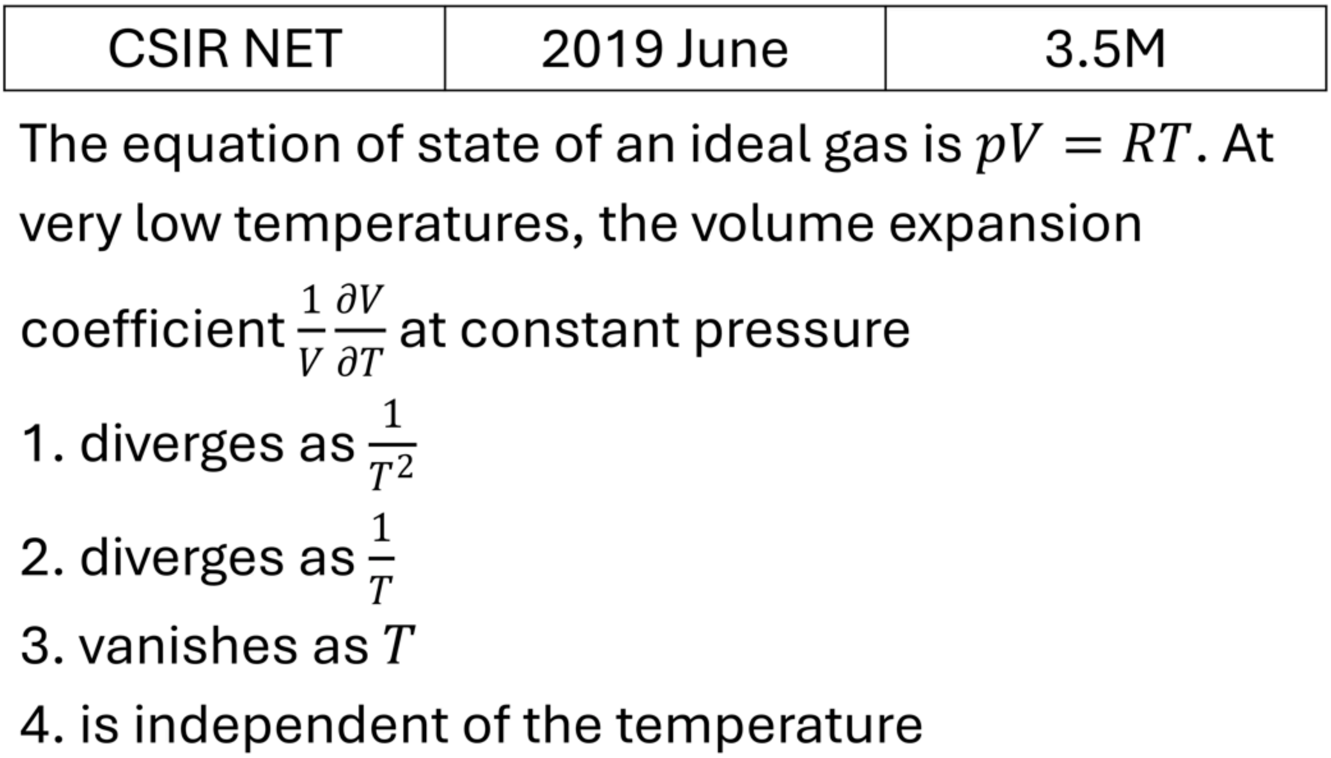
CSIR NET	2019 Dec	5M

The pressure p of a gas depends on the number density ρ of particles and the temperature T as $P = k_B T\rho - B_2\rho^2 + B_3\rho^3$ where B_2 and B_3 are positive constants. Let T_c, ρ_c and p_c denote the critical temperature, critical number density and critical pressure, respectively. The ratio $\rho_c k_B T_c/p_c$ is equal to

1. $\frac{1}{3}$
2. 3
3. $\frac{8}{3}$
4. 4

Q18. [June 2019] . 3.5 marks

Thermodynamics > Thermodynamic relations and maxwell equations



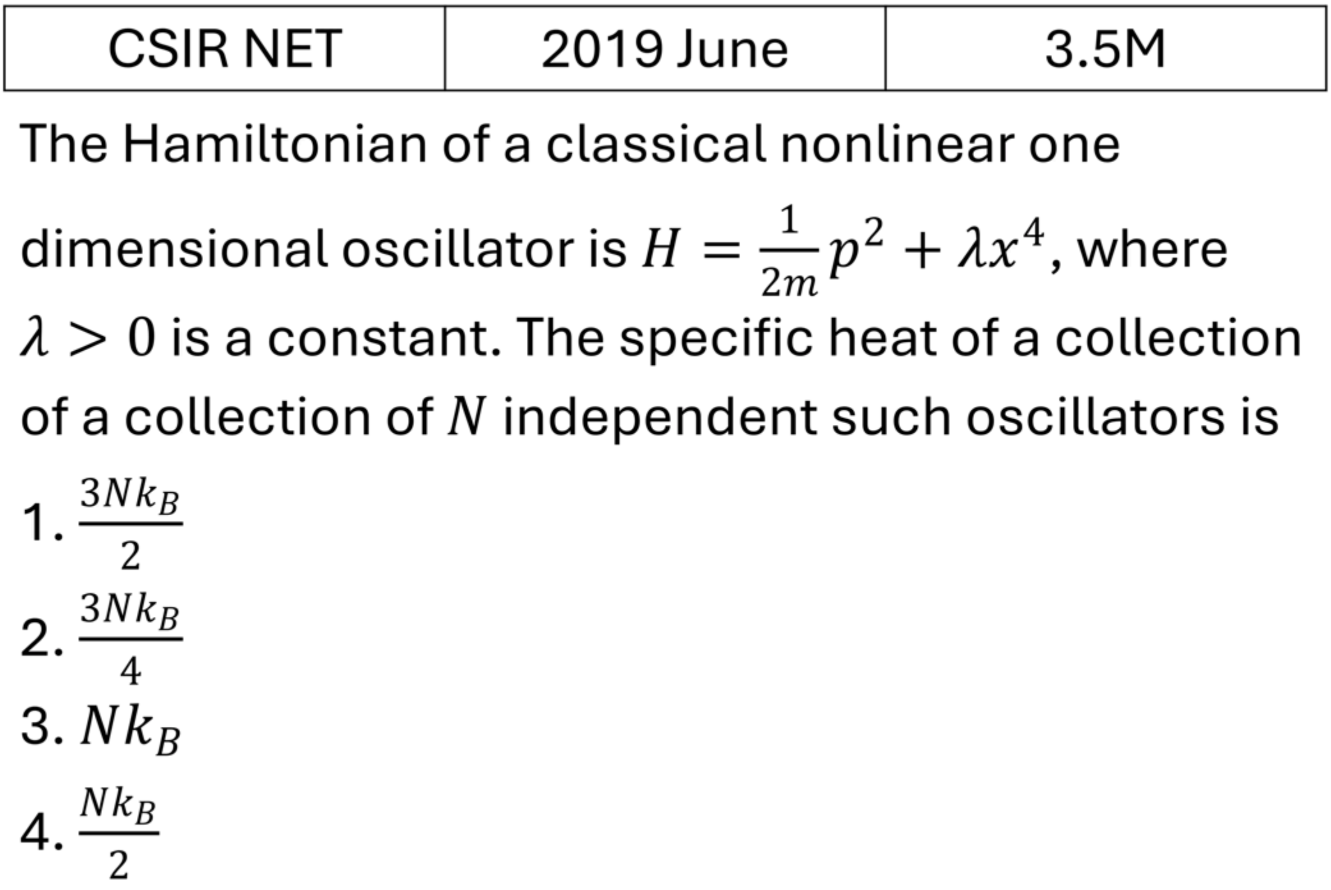
CSIR NET	2019 June	3.5M

The equation of state of an ideal gas is $pV = RT$. At very low temperatures, the volume expansion coefficient $\frac{1}{V}\frac{\partial V}{\partial T}$ at constant pressure

1. diverges as $\frac{1}{T^2}$
2. diverges as $\frac{1}{T}$
3. vanishes as T
4. is independent of the temperature

Q19. [June 2019] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



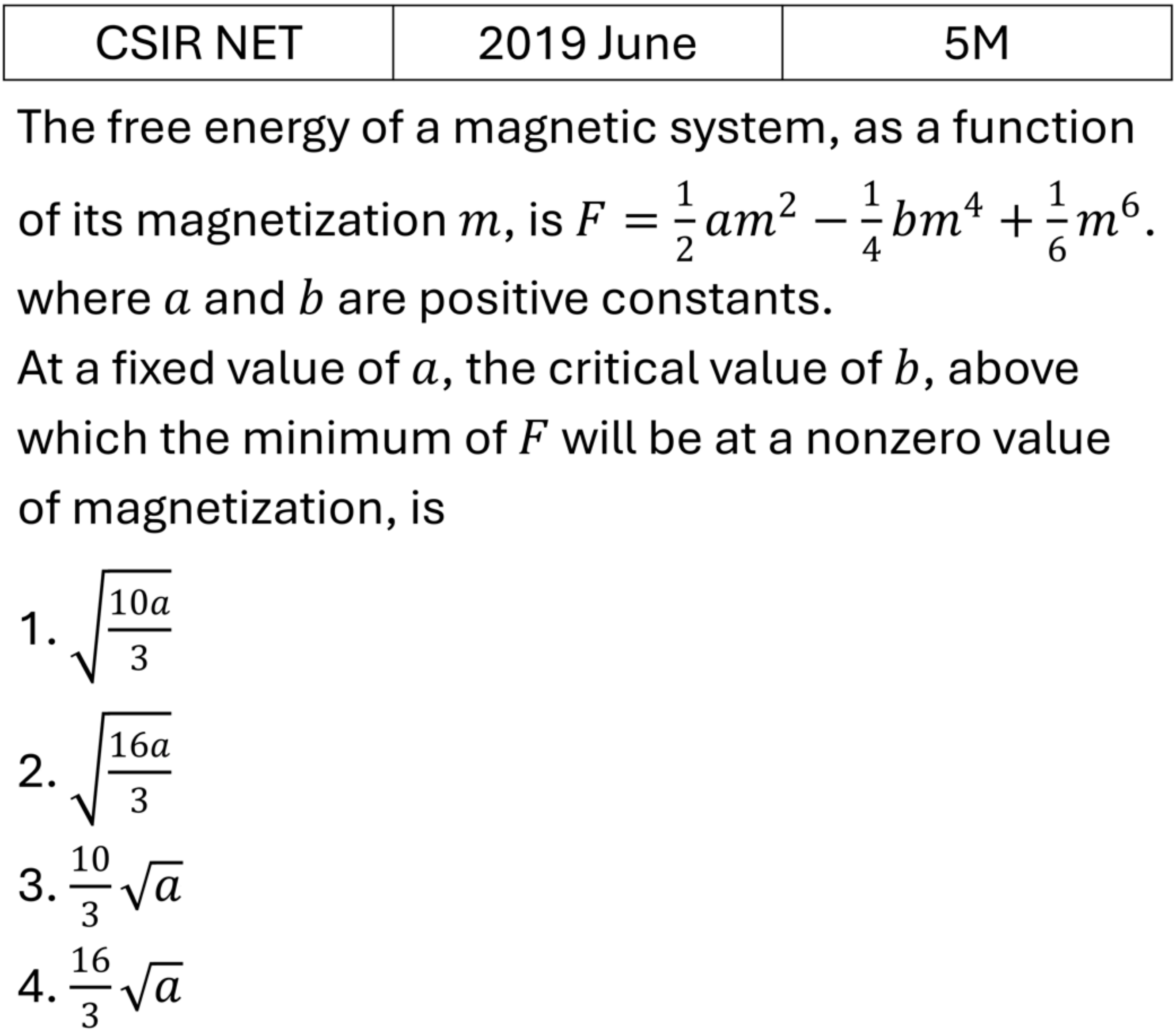
CSIR NET	2019 June	3.5M

The Hamiltonian of a classical nonlinear one dimensional oscillator is $H = \frac{1}{2m}p^2 + \lambda x^4$, where $\lambda > 0$ is a constant. The specific heat of a collection of a collection of N independent such oscillators is

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

Q20. [June 2019] . 5.0 marks

Thermodynamics > Phase transitions



CSIR NET	2019 June	5M

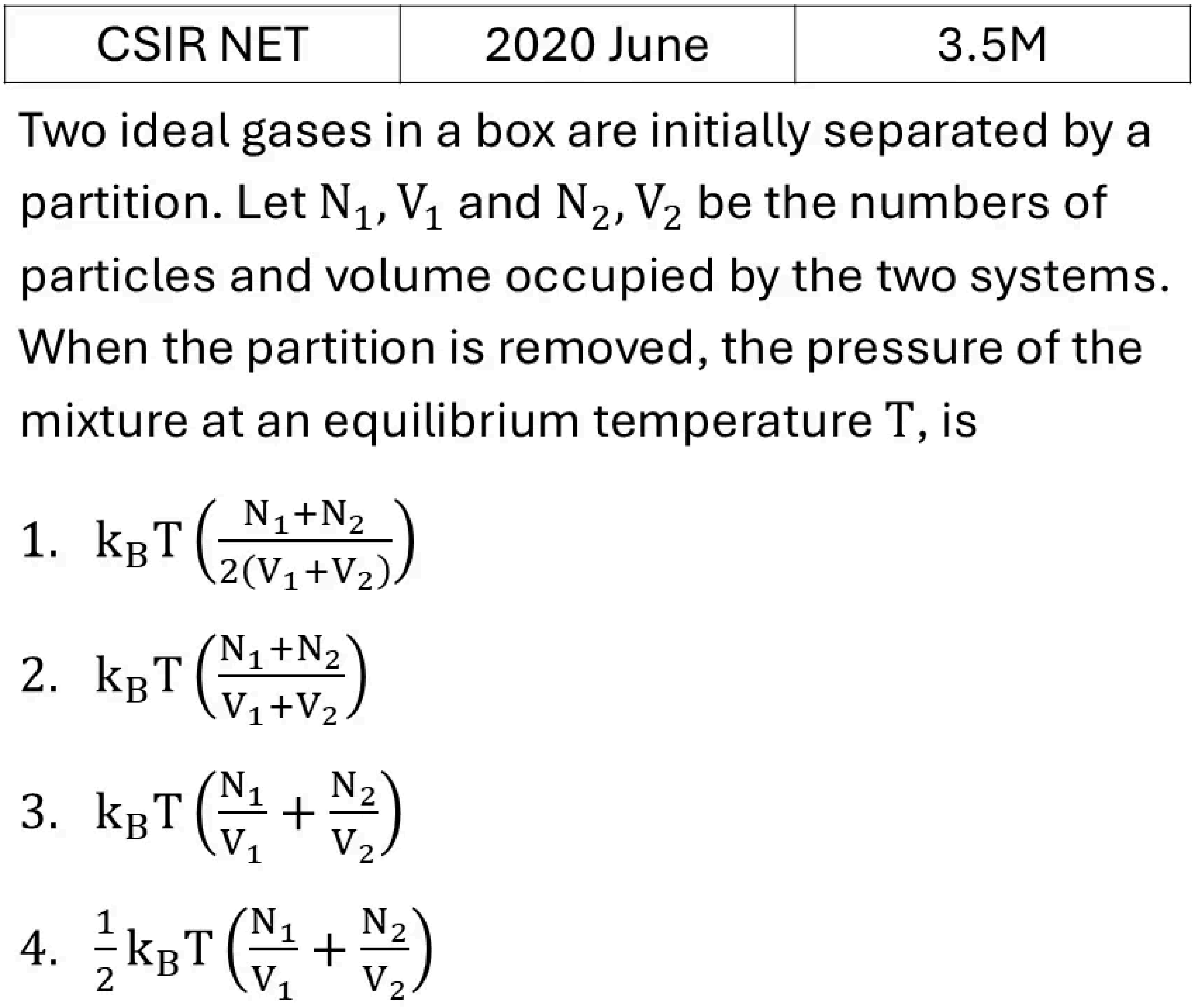
The free energy of a magnetic system, as a function of its magnetization m, is $F = \frac{1}{2}am^2 - \frac{1}{4}bm^4 + \frac{1}{6}m^6$. where a and b are positive constants.

At a fixed value of a, the critical value of b, above which the minimum of F will be at a nonzero value of magnetization, is

1. $\sqrt{\frac{10a}{3}}$
2. $\sqrt{\frac{16a}{3}}$
3. $\frac{10}{3}\sqrt{a}$
4. $\frac{16}{3}\sqrt{a}$

Q21. [June 2020] . 3.5 marks

Thermodynamics > Laws of thermodynamics



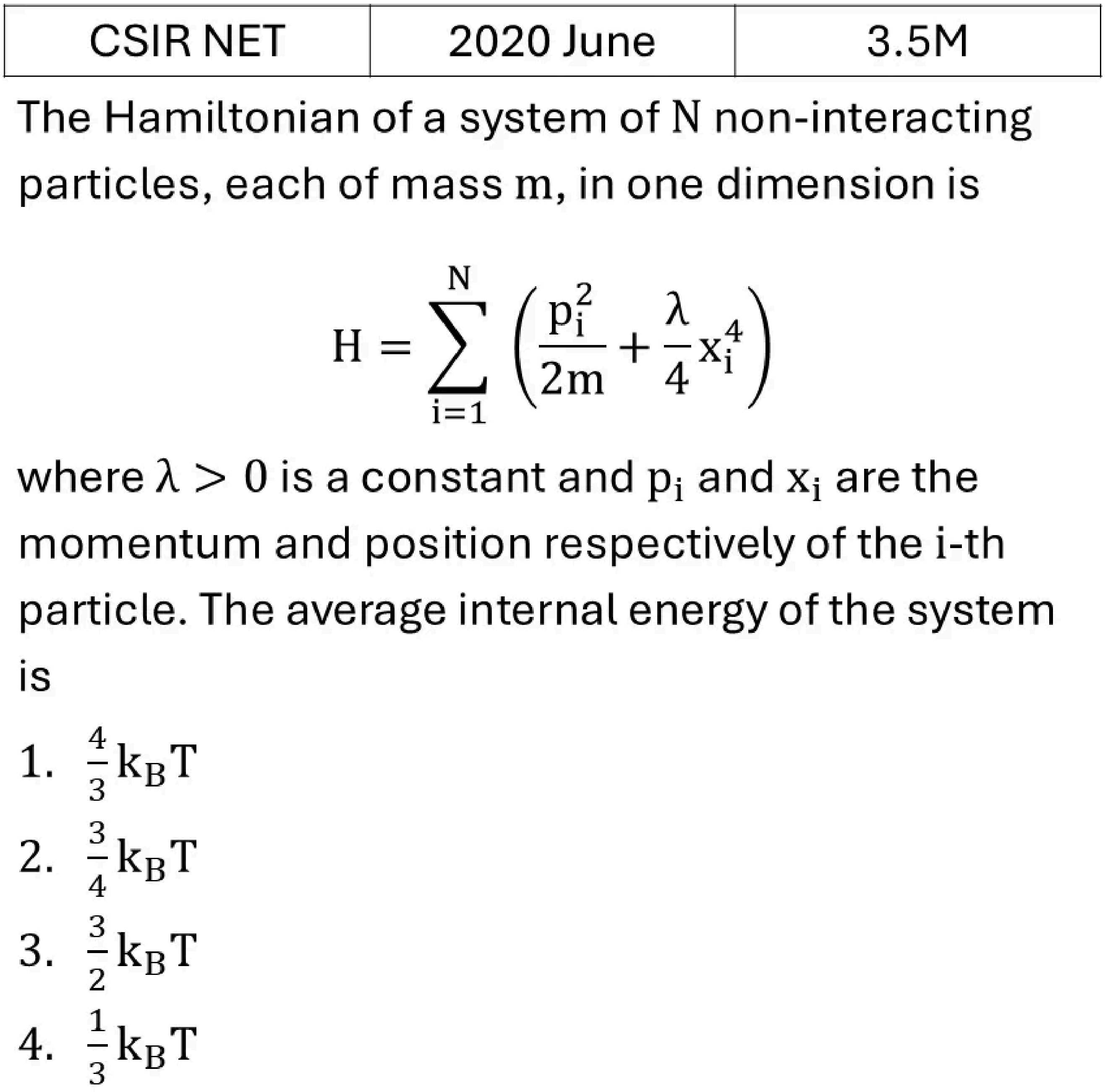
CSIR NET	2020 June	3.5M

Two ideal gases in a box are initially separated by a partition. Let N_1, V_1 and N_2, V_2 be the numbers of particles and volume occupied by the two systems. When the partition is removed, the pressure of the mixture at an equilibrium temperature T, is

1. $k_B T \left(\frac{N_1+N_2}{2(V_1+V_2)}\right)$
2. $k_B T \left(\frac{N_1+N_2}{V_1+V_2}\right)$
3. $k_B T \left(\frac{N_1}{V_1}+\frac{N_2}{V_2}\right)$
4. $\frac{1}{2} k_B T \left(\frac{N_1}{V_1}+\frac{N_2}{V_2}\right)$

Q22. [June 2020] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



CSIR NET	2020 June	3.5M

The Hamiltonian of a system of N non-interacting particles, each of mass m, in one dimension is

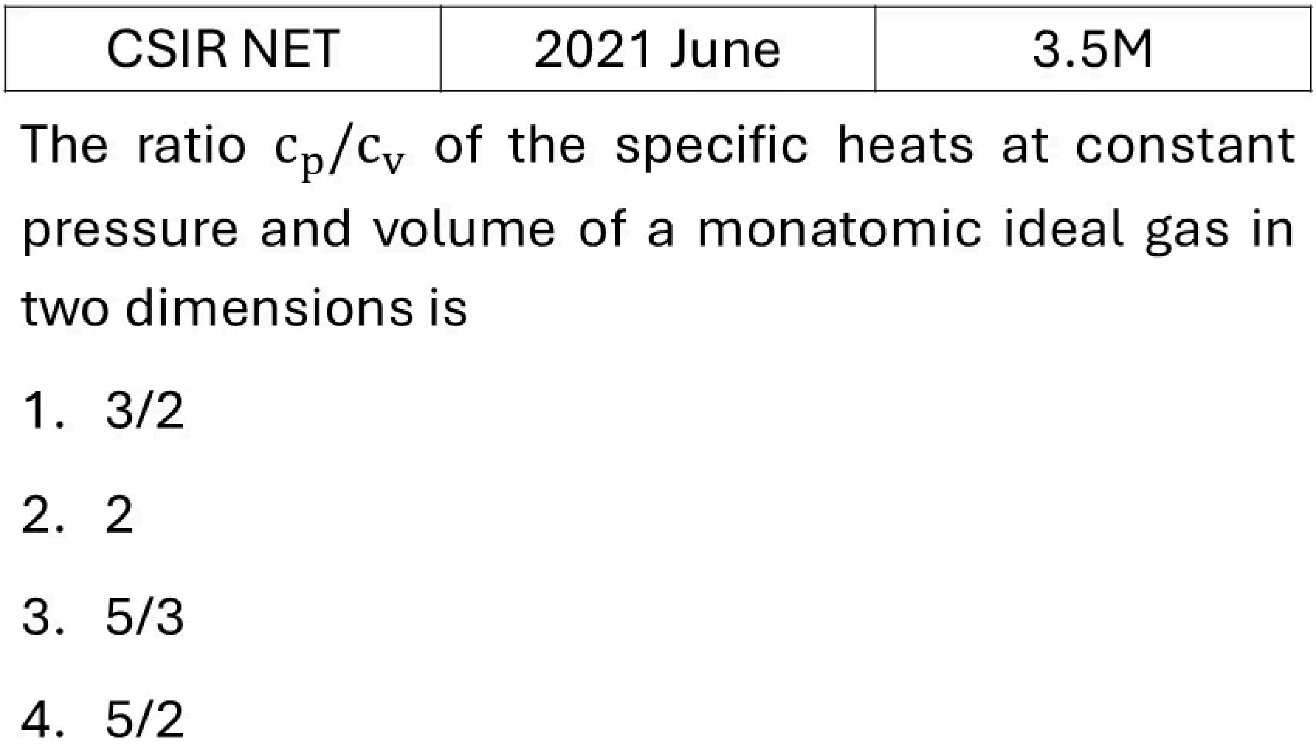
$$H = \sum_{i=1}^{N} \left(\frac{p_i^2}{2m} + \frac{\lambda}{4} x_i^4 \right)$$

where $\lambda > 0$ is a constant and p_i and x_i are the momentum and position respectively of the i-th particle. The average internal energy of the system is

1. $\frac{4}{3} k_B T$
2. $\frac{3}{4} k_B T$
3. $\frac{3}{2} k_B T$
4. $\frac{1}{3} k_B T$

Q23. [June 2021] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



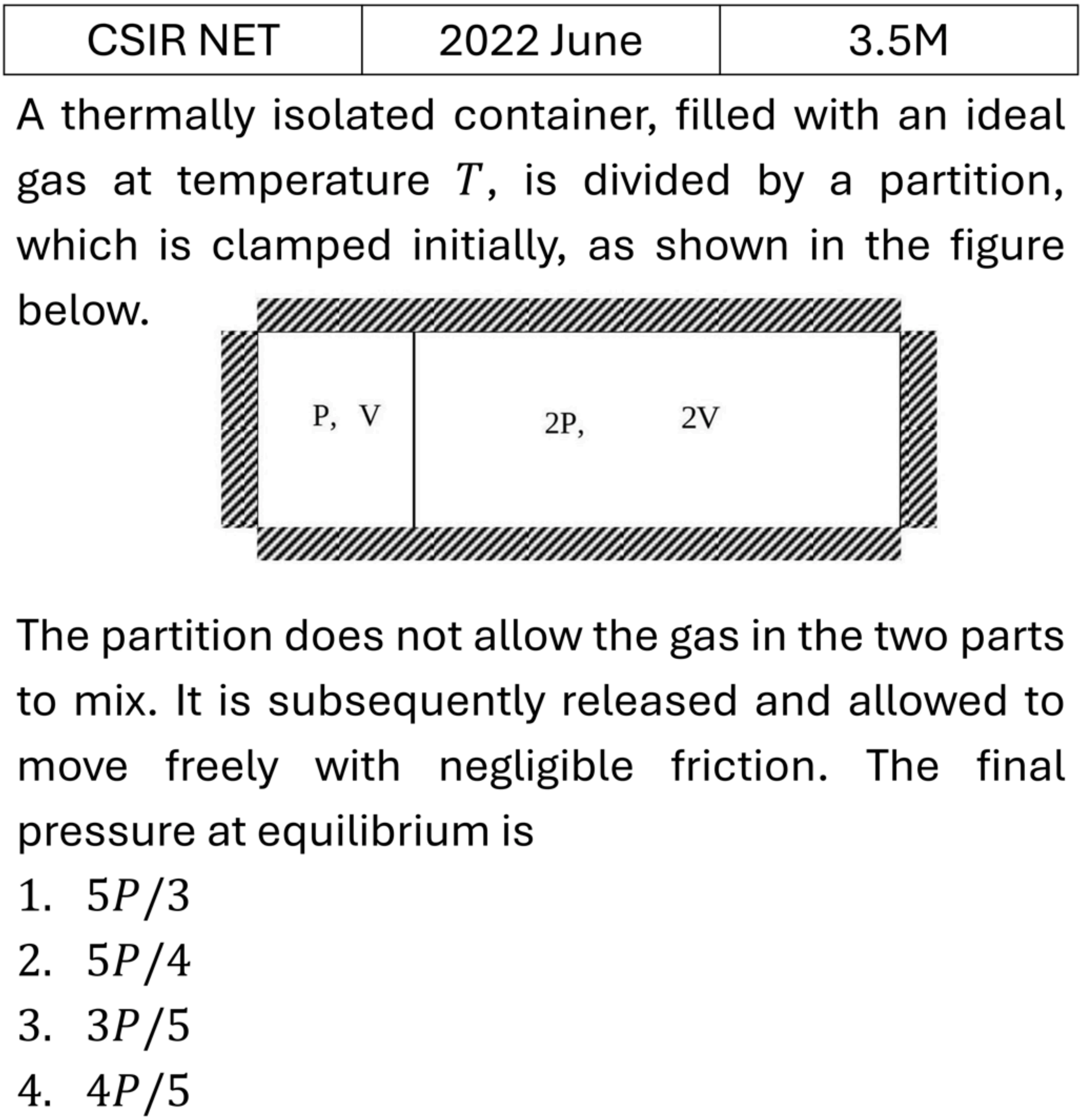
CSIR NET	2021 June	3.5M

The ratio c_p/c_v of the specific heats at constant pressure and volume of a monatomic ideal gas in two dimensions is

1. 3/2
2. 2
3. 5/3
4. 5/2

Q24. [June 2022] . 3.5 marks

Thermodynamics > Laws of thermodynamics



CSIR NET	2022 June	3.5M

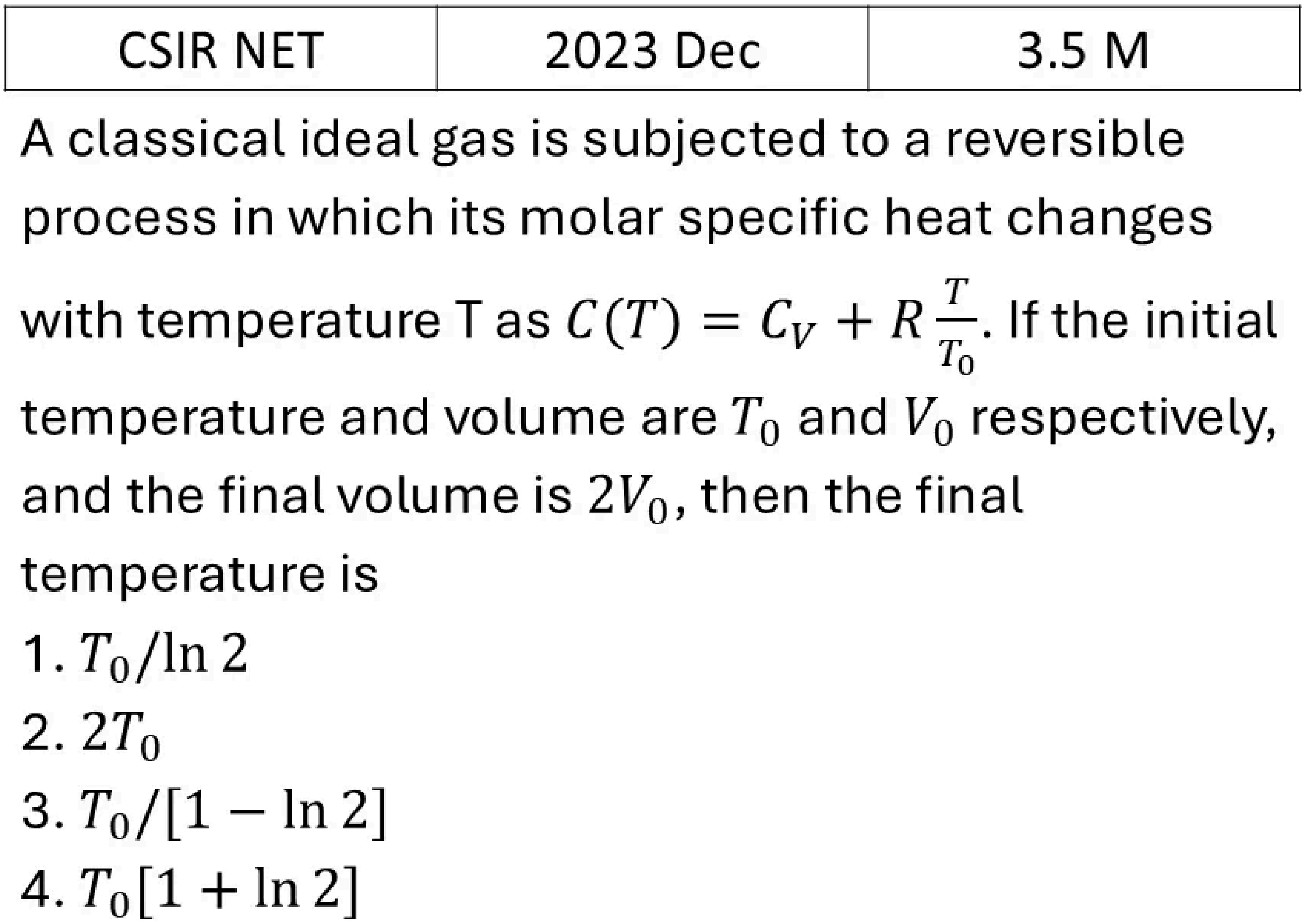
A thermally isolated container, filled with an ideal gas at temperature T, is divided by a partition, which is clamped initially, as shown in the figure below.

The partition does not allow the gas in the two parts to mix. It is subsequently released and allowed to move freely with negligible friction. The final pressure at equilibrium is

1. $5P/3$
2. $5P/4$
3. $3P/5$
4. $4P/5$

Q25. [Dec 2023] . 3.5 marks

Thermodynamics > Laws of thermodynamics



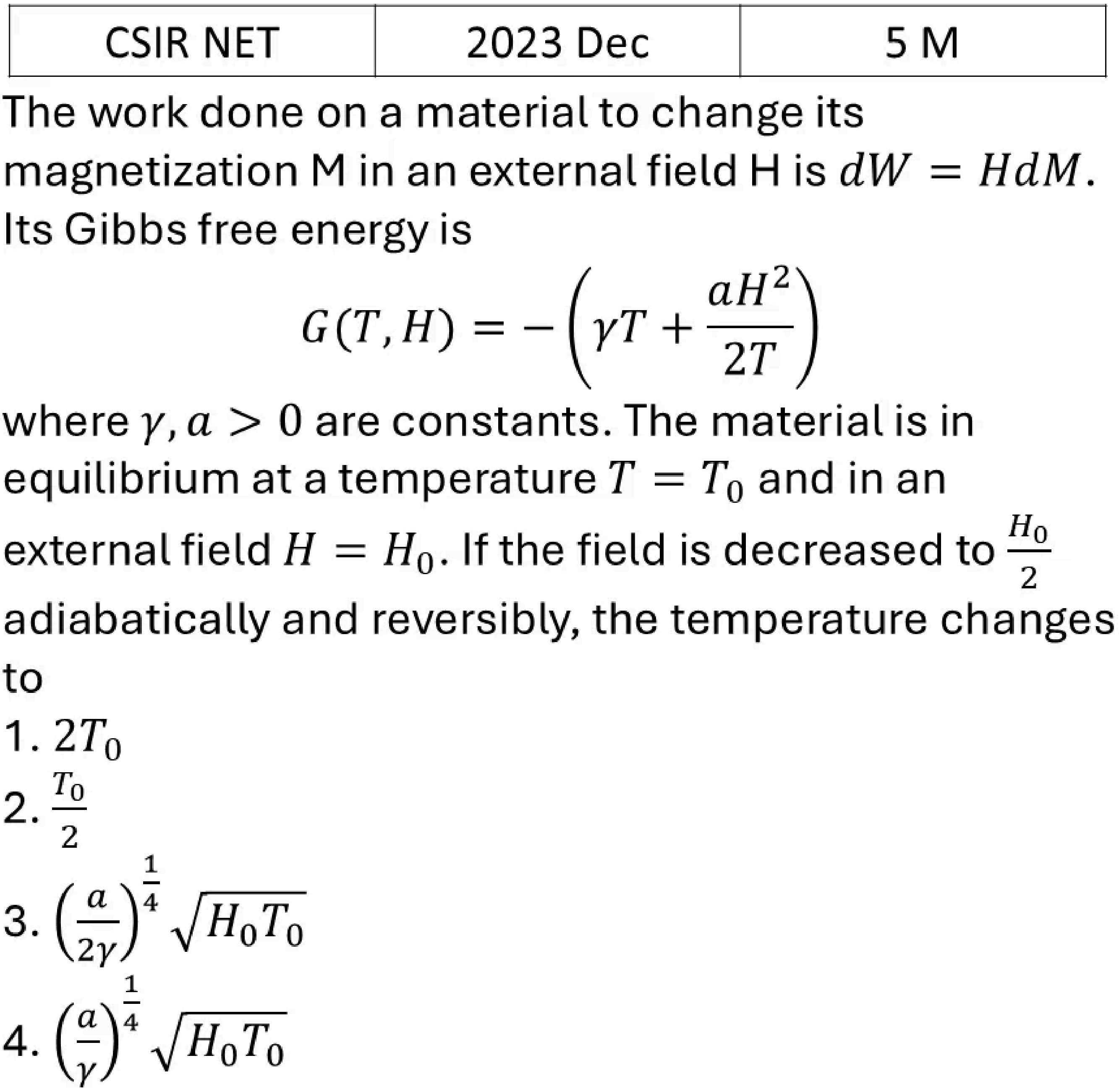
CSIR NET	2023 Dec	3.5 M

A classical ideal gas is subjected to a reversible process in which its molar specific heat changes with temperature T as $C(T) = C_V + R\frac{T}{T_0}$. If the initial temperature and volume are T_0 and V_0 respectively, and the final volume is $2V_0$, then the final temperature is

1. $T_0/\ln 2$
2. $2T_0$
3. $T_0/[1 - \ln 2]$
4. $T_0[1 + \ln 2]$

Q26. [Dec 2023] . 5.0 marks

Thermodynamics > Phase transitions



CSIR NET	2023 Dec	5 M

The work done on a material to change its magnetization M in an external field H is $dW = HdM$. Its Gibbs free energy is

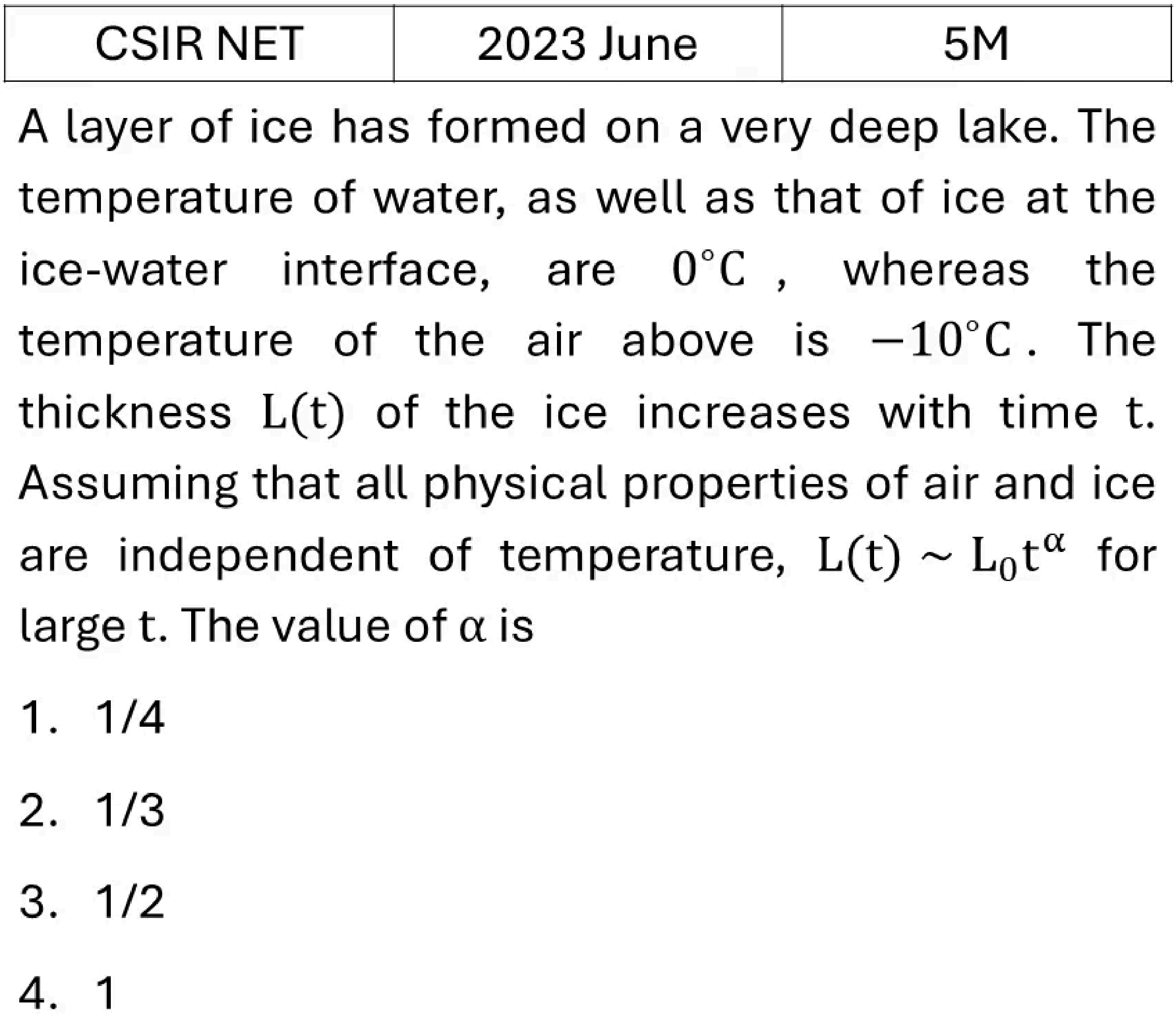
$$G(T,H) = -\left(\gamma T + \frac{aH^2}{2T}\right)$$

where $\gamma, a > 0$ are constants. The material is in equilibrium at a temperature $T = T_0$ and in an external field $H = H_0$. If the field is decreased to $\frac{H_0}{2}$ adiabatically and reversibly, the temperature changes to

1. $2T_0$
2. $\frac{T_0}{2}$
3. $\left(\frac{a}{2\gamma}\right)^{\frac{1}{4}}\sqrt{H_0T_0}$
4. $\left(\frac{a}{\gamma}\right)^{\frac{1}{4}}\sqrt{H_0T_0}$

Q27. [June 2023] . 5.0 marks

Thermodynamics > Phase transitions



CSIR NET	2023 June	5M

A layer of ice has formed on a very deep lake. The temperature of water, as well as that of ice at the ice-water interface, are $0^\circ\mathrm{C}$, whereas the temperature of the air above is $-10^\circ\mathrm{C}$. The thickness $\mathrm{L(t)}$ of the ice increases with time t. Assuming that all physical properties of air and ice are independent of temperature, $\mathrm{L(t)} \sim \mathrm{L_0 t^\alpha}$ for large t. The value of α is

1. 1/4
2. 1/3
3. 1/2
4. 1

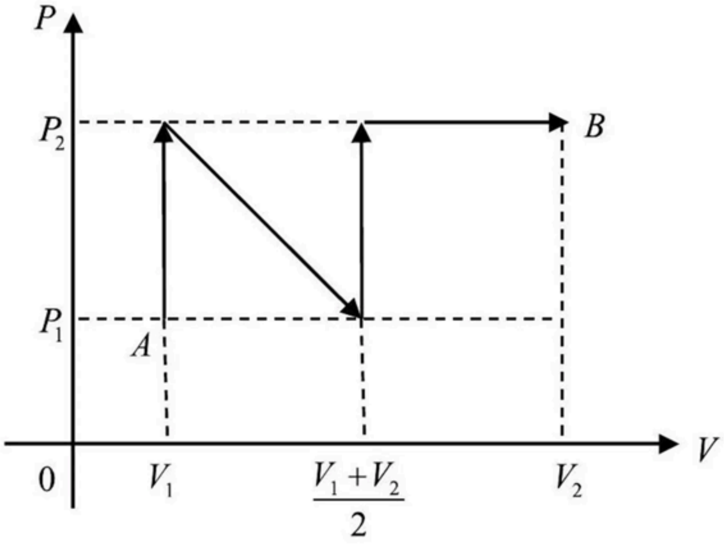
Q28. [June 2024] . 3.5 marks

Thermodynamics > Laws of thermodynamics

CSIR NET	2024 June	3.5M

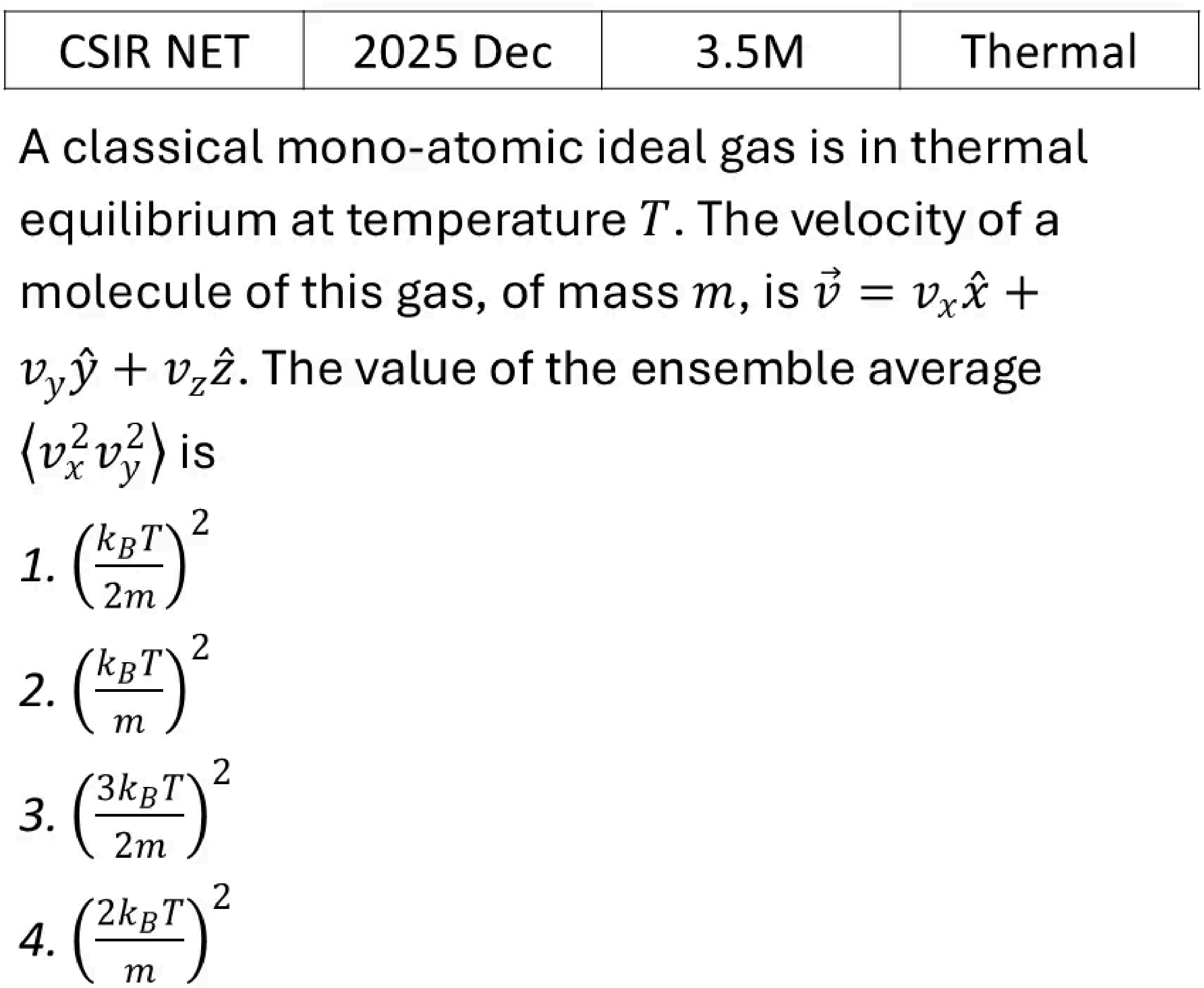
The following $P - V$ diagram shows a process, where an ideal gas is taken quasi-statically from A to B along the path as shown in the figure. The work done W in this process is

1. $\frac{1}{4}(V_2 - V_1)(3P_2 + P_1)$
2. $\frac{1}{4}(V_2 - V_1)(3P_2 - P_1)$
3. $\frac{1}{2}(V_2 - V_1)(P_1 + P_2)$
4. $\frac{1}{2}(V_2 + V_1)(P_2 - P_1)$



Q29. [Dec 2025] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



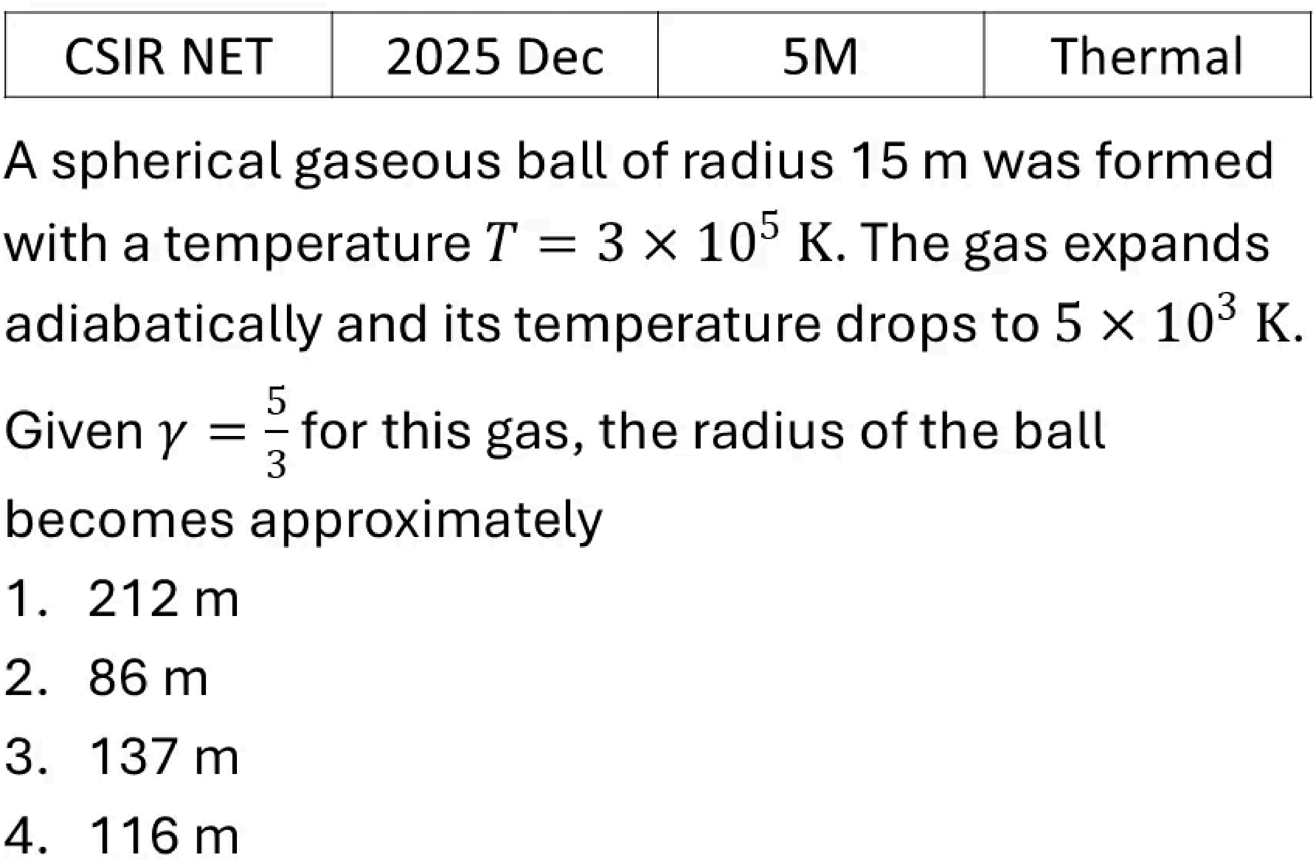
CSIR NET	2025 Dec	3.5M	Thermal

A classical mono-atomic ideal gas is in thermal equilibrium at temperature T. The velocity of a molecule of this gas, of mass m, is $\vec{v} = v_x\hat{x} + v_y\hat{y} + v_z\hat{z}$. The value of the ensemble average $\langle v_x^2 v_y^2 \rangle$ is

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

Q30. [Dec 2025] . 5.0 marks

Thermodynamics > Laws of thermodynamics



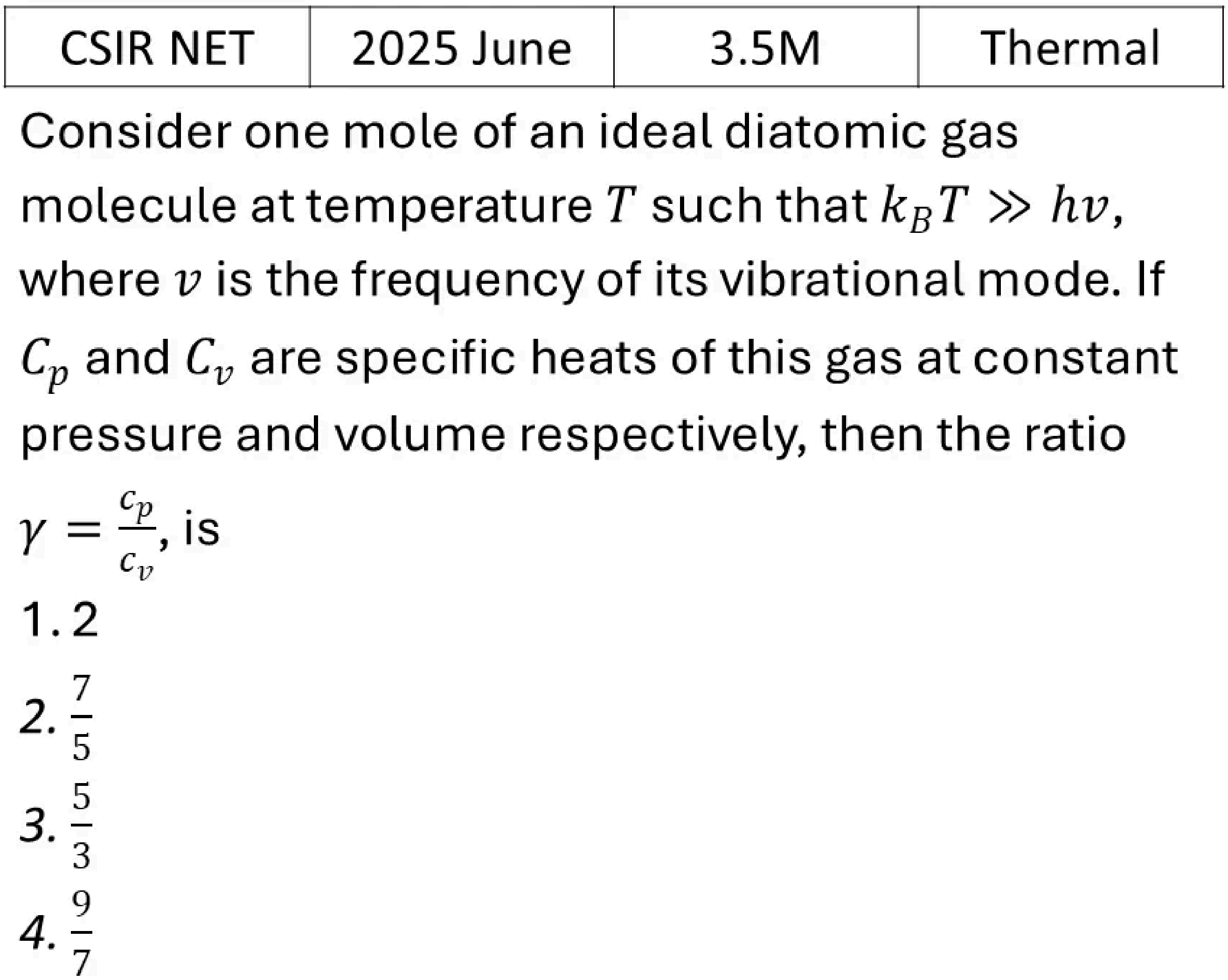
CSIR NET	2025 Dec	5M	Thermal

A spherical gaseous ball of radius 15 m was formed with a temperature $T = 3 \times 10^5$ K. The gas expands adiabatically and its temperature drops to 5×10^3 K. Given $\gamma = \frac{5}{3}$ for this gas, the radius of the ball becomes approximately

1. 212 m
2. 86 m
3. 137 m
4. 116 m

Q31. [June 2025] . 3.5 marks

Thermodynamics > Kinetic theory of Gases



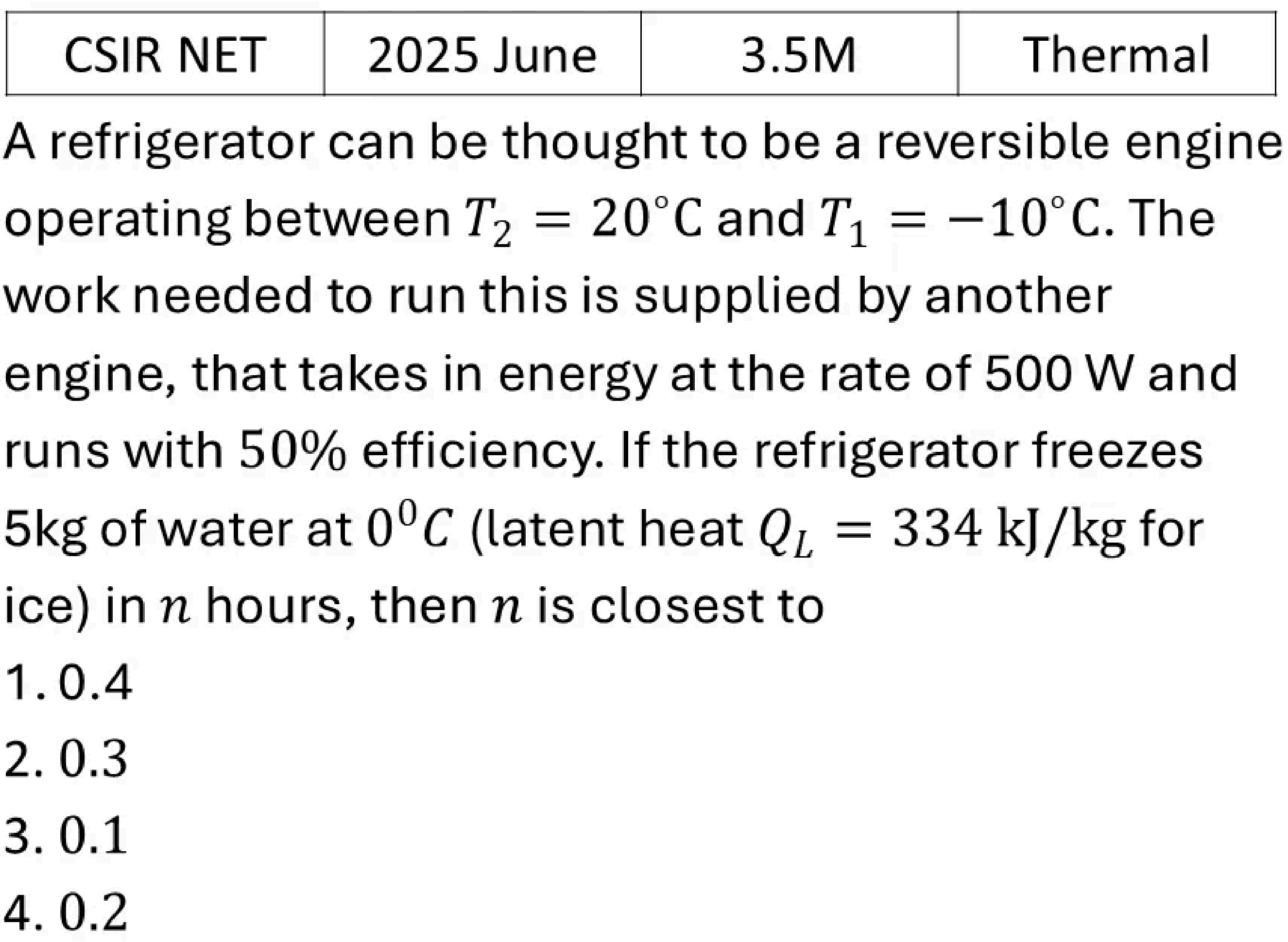
CSIR NET	2025 June	3.5M	Thermal

Consider one mole of an ideal diatomic gas molecule at temperature T such that $k_BT \gg hv$, where v is the frequency of its vibrational mode. If C_p and C_v are specific heats of this gas at constant pressure and volume respectively, then the ratio $\gamma = \frac{c_p}{c_v}$, is

1. 2
2. $\frac{7}{5}$
3. $\frac{5}{3}$
4. $\frac{9}{7}$

Q32. [June 2025] . 3.5 marks

Thermodynamics > Carnot Cycle



CSIR NET	2025 June	3.5M	Thermal

A refrigerator can be thought to be a reversible engine operating between $T_2 = 20^\circ\mathrm{C}$ and $T_1 = -10^\circ\mathrm{C}$. The work needed to run this is supplied by another engine, that takes in energy at the rate of 500 W and runs with 50% efficiency. If the refrigerator freezes 5kg of water at $0^0 C$ (latent heat $Q_L = 334\ \mathrm{kJ/kg}$ for ice) in n hours, then n is closest to

1. 0.4
2. 0.3
3. 0.1
4. 0.2

Answer Key

32 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Thermodynamics	Carnot Cycle	**4**
Q2	Thermodynamics	Phase transitions	**2**
Q3	Thermodynamics	Phase transitions	**1&3**
Q4	Thermodynamics	Kinetic theory of Gases	**3**
Q5	Thermodynamics	Kinetic theory of Gases	**2**
Q6	Thermodynamics	Laws of thermodynamics	**2**
Q7	Thermodynamics	Kinetic theory of Gases	**2**
Q8	Thermodynamics	Thermodynamic relations and maxwell equations	**1**
Q9	Thermodynamics	Thermodynamic relations and maxwell equations	**1**
Q10	Thermodynamics	Laws of thermodynamics	**None**
Q11	Thermodynamics	Thermodynamic relations and maxwell equations	**1**
Q12	Thermodynamics	Laws of thermodynamics	**1**
Q13	Thermodynamics	Phase transitions	**3**
Q14	Thermodynamics	Laws of thermodynamics	**3**
Q15	Thermodynamics	Laws of thermodynamics	**4**
Q16	Thermodynamics	Carnot Cycle	**3**
Q17	Thermodynamics	Kinetic theory of Gases	**2**
Q18	Thermodynamics	Thermodynamic relations and maxwell equations	**2**
Q19	Thermodynamics	Kinetic theory of Gases	**2**
Q20	Thermodynamics	Phase transitions	**2**
Q21	Thermodynamics	Laws of thermodynamics	**2**
Q22	Thermodynamics	Kinetic theory of Gases	**2**
Q23	Thermodynamics	Kinetic theory of Gases	**2**
Q24	Thermodynamics	Laws of thermodynamics	**1**
Q25	Thermodynamics	Laws of thermodynamics	**4**
Q26	Thermodynamics	Phase transitions	**2**
Q27	Thermodynamics	Phase transitions	**3**
Q28	Thermodynamics	Laws of thermodynamics	**1**
Q29	Thermodynamics	Kinetic theory of Gases	**2**
Q30	Thermodynamics	Laws of thermodynamics	**4**
Q31	Thermodynamics	Kinetic theory of Gases	**4**
Q32	Thermodynamics	Carnot Cycle	**4**