

IISER Kolkata  
Mid-Semester Examination  
Third Year Semester II  
PH3201 (Basic Statistical Mechanics) .  
Time: 1 hour 30 minutes; Full Marks 20  
Answer all questions

1. Write down the Hamiltonian of a particle of mass  $m$  thrown vertically up with some initial velocity. Sketch the phase space diagram.
2. Take  $10^{-6}$  J of heat from a system at a temperature of 300 K and add it to a system at 299 K. Find the change of entropy. By what factor does the number of accessible states change?
3. The entropy  $S$  of a system is given by the formula  $S = \frac{4}{3}\sigma V^{\frac{1}{3}} E^{\frac{2}{3}}$  where  $\sigma$  is a constant and  $E, V$  are the energy and volume respectively. Find the temperature of the system. Can you identify the system?
4. A system has non-degenerate energy levels with energy  $E_n = (n + \frac{1}{2})\epsilon$  where  $\epsilon = 1.4 \times 10^{-23}$  J and  $n$  is a positive integer or zero. What is the probability that the system is in the state  $n = 1$  if it is in contact with a heat bath at 1K ?
5. For a classical gas containing  $N$  molecules, the canonical partition function is given as  $Z = \left(\frac{V_N b}{N}\right)^N \left(\frac{2\pi m k_B T}{h^2}\right)^{\frac{3N}{2}} e^{-\frac{N^2 a^2}{V k_B T}}$ , where  $V$  and  $T$  are the volume and temperature and  $a, b, k_B, m, h$  are all constants. Find out an expression for the pressure of the gas. From the equation of state, can you recognize the gas?
6. A set of  $N$  indistinguishable particles is given by the quantum state  $\psi = \psi(s_1, s_2, \dots, s_n)$  where  $s_i$  is a set of quantum numbers for the  $i$ th particle. Show that  $\psi$  has to be either symmetric or antisymmetric under exchange of particles.

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20/2/19