Question Bank for Thermodynamics & Statistical Mechanics

(As per CBCS Syllabus)

Part A (1 mark each)

1- The total number of accessible states of 'N' non interacting particles of spin ½ is _____.

2- The dimension of phase space of 10 rigid diatomic molecules is _____.

3- A monoatomic ideal gas at 17 degree C is adiabatically compressed to 1/8 of its original volume. The temperature after compression is,

(a) 2.1 degree C (c) 17 degree C

(b) -200.5 degree C (d) 887 degree C

4- For which gas ratio of specific heats (C_P/C_v) will be largest,

(a) Monoatomic (c) Triatomic

(b) Diatomic (d) Hexa-atomic

5- Efficiency of a perfectly reversible (Carnot) heat engine operating between absolute temperature T and zero is equal to, _____.

6- The specific heat at constant volume per molecule of a gas of diatomic molecules at high temperature is,

(a) $8K_B$ (c) $4.5\ K_B$

(b) $3.5\ K_B$ (d) $3K_B$

7- A system has energy level E_0, $2E_0$, $3E_0$, ……,where the excited states are triply degenerate 4 non-interacting Bosons are placed in the systems. If total energy of these Bosons is $5E_0$ the number of microstates is,

(a) 2 (c) 4

(b) 3 (d) 5

8- The phase space trajectory of a free particle bouncing between two hard walls elastically in one dimension is a,

(a) Straight line (c) rectangle

(b) Parabola (d) circle

9- Two solid spheres A and B have same emissivity the radius of A is 4 times the radius of B and temperature of A is twice the temperature of B. The ratio of the rate of heat radiated from A to B is _____.

10- Consider a system of 3 fermions, which can occupy any of the 4 available energy states with equal probability. The entropy of the system is,

(a) $K_B \ln 2$ (c) $3K_B \ln 2$

(b) $2K_B \ln 2$ (d) $3K_B \ln 4$

11- At a given temperature T, the average energy per particle of non-interacting gas of 2 dimensional classical harmonic oscillator is _____$K_B T$.

12- The energy dependence of the density of states for a two dimensional non-relativistic electron gas is given by, $g(E) = CE^n$, where C is a constant. The value of 'n' is _____.

13- The pressure of a non-relativistic free Fermi gas in 3 dimension depends, at T=0 and the density of state of fermions 'n' as,

(a) $n^{5/3}$ (c) $n^{2/3}$

(b) $n^{1/3}$ (d) $n^{4/3}$

14- For a system of independent non-interacting one dimensional oscillators, the value of the free energy per oscillator, in the Limit $T \rightarrow 0$ is _____.

15- In two dimensions two metals A and B, have a number density of free electrons in the ratio $n_A : n_B = 1:2$. Ratio of there Fermi energy is _____.

Part B (2 marks each)

1- In a first order phase transition at the transition temperature, specific heat of the system,

(a) Diverges and it's entropy remains same

(b) Diverges and it's entropy has finite discontinuity

(c) Remains unchanged and it's entropy has finite discontinuity.

(d) Has finite discontinuity and it's entropy diverges.

2- The average speed of molecules in a gas at 20 degree C is v. At what temperature it will be 2v.

(a) 899 degree C

(b) 586 degree C

(c) 80 degree C

(d) 40 degree C

3- When a crystal melts into liquid at constant pressure which of the following quantities changes continuously at the phase transition.

(a) Gibbs free energy

(b) Volume

(c) Internal energy

(d) Entropy

4- In Bose-Einstein condensation, the particles,

(a) Have strong inter-particle attraction

(b) Condense in real space

(c) Have overlapping wave function

(d) Have large and positive chemical potential

5- The number of ways in which 5 identical Bosons can be distributed in 4 states is _____.

6- Black body radiation is enclosed inside a spherical cavity of radius R at temperature T. What would be the temperature of the enclosure if the radius expands to 2R adiabatically.

(a) T/2 (b) 2T (c) 3T (d) 4T

7- Three identical spin ½ fermions are to be distributed in two non-degenerate distinct energy level. The number of ways this can be done is _____.

8- A random walker takes a step of unit length in the positive direction with probability 2/3 and a step of unit length in the negative direction with probability 1/3. The mean displacement of the walker after 'n' step is,

(a) n/3 (b) n/8 (c) 2n/3 (d) n/16

9- When a collection of two level system is in equilibrium at temperature T_0, the ratio of population in the lower and upper level is 2:1. When the temperature is changed to T the ratio is 8:1. Then,

(a) $T=2T_0$

(b) $T_0=2T$

(c) $T_0=3T$

(d) $T_0=4T$

10- If V_{avg}, V_p and V_{rms} denote the average, most probable and root mean square values respectively of the molecular speeds of gas at room temperature being Maxwellian velocity distribution, then,

(a) $V_{avg} < V_p < V_{rms}$

(b) $V_{rms} < V_{avg} < V_p$

(c) $V_{rms} < V_p < V_{avg}$

(d) $V_p < V_{avg} < V_{rms}$

11- Which of the following is an example of a first order phase transition,

(a) A liquid-gas phase transition at the critical point

(b) A paramagnet-ferromagnet phase transition

(c) A normal metal-superconductor phase transition

(d) A liquid gas phase transition away from critical point

12- A heat pump working on the Carnot cycle maintains the inside temperature of a house at 22 degree C by suppling 450 KJS^{-1}. If the outside temperature is zero degree C, the heat taken in KJS^{-1}, from the outside air is approximately,

(a) 487 (b) 470 (c) 467 (d) 417

13- An ideal gas undergoes an isothermal expansion (at a constant temperature T) from an initial volume C to a final volume V_2. The change in the entropy per mole is,

(a) $R(V_1/V_2)$

(b) $R \ln | V_1-V_2 |$

(c) $R \ln (V_1/V_2)$

(d) $R \ln (V_2/V_1)$

14- Consider a linear collection of N independent spin ½ particles, each at fixed location. The entropy of the system is (k is the Boltzmann constant)

(a) Zero (b) Nk (c) ½ Nk (d) Nk ln(2)

15- A two level system has energies zero and E. The level with zero energy is non-degenerate, while the level with energy E is triply degenerate. The mean energy of classical particle in this system at a temperature T is,

(a) $\frac{Ee^{-E/k_BT}}{1+3e^{-E/k_BT}}$

(b) $\frac{Ee^{-E/k_BT}}{1+e^{-E/k_BT}}$

(c) $\frac{3Ee^{-E/k_BT}}{1+e^{-E/k_BT}}$

(d) $\frac{3Ee^{-E/k_BT}}{1+3e^{-E/k_BT}}$