Quantum & Statistical Mechanics II

Class Test I : 07.11.2017

Total Marks - 25, Time - 30 Minutes

Special Instruction : Calculators are not to be used.

Multiple Choice : 1.0 x 10 = 10.0

1. Work done, in a free expansion process, is -
   (a) zero
   (b) minimum
   (c) maximum
   (d) positive
2. The ratio of the specific heat at constant pressure (C_P) and the specific heat at constant volume (C_V) is -
   (a) equal to one
   (b) less than one
   (c) greater than one
   (d) none of these
3. If the value of $n = 0$ in the equation $PV^n = C$, then the process is called
   (a) constant volume process
   (b) adiabatic process
   (c) constant pressure process
   (d) isothermal process
4. The area under the temperature-entropy curve ($T - S$ curve) of any thermodynamic process represents
   (a) none of these
   (b) heat rejected
   (c) heat absorbed
   (d) either heat absorbed or heat rejected
5. The efficiency of Joule cycle is
   (a) greater than Carnot cycle
   (b) less than Carnot cycle
   (c) equal to Carnot cycle
   (d) none of these
6. In a thermodynamic system, what is the conjugate intensive variable of volume?
   (a) entropy
   (b) temperature
   (c) pressure
   (d) chemical potential
7. The main cause for the irreversibility is
   (a) mechanical and fluid friction
   (b) unrestricted expansion
   (c) heat transfer with a finite temperature difference
   (d) all of the above

8. If a process is endothermic and spontaneous, which of the following must be true?
   (a) $\Delta G > 0$ and $\Delta H > 0$
   (b) $\Delta G > 0$ and $\Delta H < 0$
   (c) $\Delta G > 0$ and $\Delta S > 0$
   (d) $\Delta H > 0$ and $\Delta S > 0$
9. The temperatures (T_1, T_2, T_3) of a primordial black hole, a stellar remnant and an active galactic centre would have the following relation -
   (a) $T_1 > T_2 > T_3$
   (b) $T_1 = T_2 = T_3$
   (c) $T_1 < T_2 < T_3$
   (d) none of the above
10. On a phase diagram, the temperature and pressure at which the phase boundary between the liquid and gas ceases to exist is -
   (a) boiling point
   (b) critical point
   (c) sublimation point
   (d) triple point

Short Questions : 2.5 x 2 = 5.0

1. Consider an ideal gas of N monatomic molecules in a volume V and energy E. Find the number of micro-states $\Omega(E)$ as a function of E.
2. Derive the expression for average energy of an open system which is described by the grand canonical ensemble formalism.

Medium Questions : 5.0 x 2 = 10.0

1. Consider a system consisting of 4 spin particles. Each particle has a magnetic moment μ which can point either up or down. The total magnetic moment of the system is noted as M.
   (a) How many spin configurations (i.e., number of microscopic states) can the system have? Assume the particles to be distinguishable.
   (b) How many different values (i.e., the number of macroscopic states) can M take?
   (c) What is the proba bility of $M = 0$ in this system?
2. A particular gas is described by such an equation of state: $PV^2 = aT$, where a is a constant. For this gas, the heat capacity at constant volume C_V is constant. When the gas evolves quasistatically from the initial state of temperature T_i and volume V_i to the final state of temperature T_f and volume V_f,.
   (a) Find the change in its entropy ΔS.
   (b) Find the change in its internal energy ΔE.

Physical & Astrophysical Data :

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\begin{aligned}
c &= 3 \times 10^{10} cms^{-1} \\
G &= 6.6732 \times 10^{-8} cgs \\
\hbar &= 1.0546 \times 10^{-27} cgs \\
m_p &= 1.6726 \times 10^{-24} gm \\
m_e &= 9.1095 \times 10^{-28} gm \\
\mathrm{M}_\odot &= 1.989 \times 10^{33} gm \\
e &= 4.8032 \times 10^{-10} cgs
\end{aligned}
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