153. If wave function of a particle confined in a box of length a is $\psi(x) = \sqrt{\frac{2}{a}} \sin\frac{\pi x}{a}$; $0 \le x \le a$, then the probability of finding particle in the region $0 < x < \frac{a}{2}$ is

(A) 0.5
(B) 0.6
(C) 0.7
(D) 0.8

154. The normalized wave function of a particle is given by $\psi(x) = \frac{1}{\sqrt{2}\,x}\left(\frac{1+ix}{1+ix^2}\right)$ then the particle is more likely to be found at

(A) $x = \pm\sqrt{\sqrt{2} - 1}$
(B) $x = \pm\sqrt{\sqrt{3} - 1}$
(C) $x = \pm\sqrt{\sqrt{2} - 2}$
(D) $x = \pm\sqrt{\sqrt{3} - 2}$

155. If P_x is component of linear momentum corresponding to a position coordinate x, then the commutator $[x, P_x^2]$ is

(A) $i\hbar p_x$
(B) $i\hbar 2p_x$
(C) $i\hbar 3p_x$
(D) $i\hbar 4p_x$

156. For a hydrogen atom, the Coulomb degeneracy for the n = 3 state is

(A) 3
(B) 6
(C) 8
(D) 9

157. The uncertainty relation for a free particle can be written as

(A) $\Delta\lambda.\Delta x \ge \frac{\lambda^2}{\pi}$
(B) $\Delta\lambda.\Delta x \ge \frac{\lambda^2}{2\pi}$
(C) $\Delta\lambda.\Delta x \ge \frac{\lambda}{2\pi}$
(D) $\Delta\lambda.\Delta x \ge \frac{\lambda^2}{4\pi}$

158. In hydrogenic states, the probability of finding the electron at r = 0 is

(A) zero in state $\phi_{1s}(r)$
(B) non-zero in state $\phi_{2s}(r)$
(C) zero in state $\phi_{2p}(r)$
(D) zero in state $\phi_{3p}(r)$

159. The quantum mechanical operator for the momentum of a particle moving in one dimension can be given by

(A) $i\hbar\frac{d}{dx}$
(B) $i\hbar\frac{\partial}{\partial t}$
(C) $-i\hbar\frac{d}{dx}$
(D) $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$

160. The possible j values for $l = 3$ and $s = \frac{1}{2}$ are

(A) $j = \frac{3}{2}, \frac{5}{2}, \frac{7}{2}$ (B) $j = \frac{3}{2}, \frac{5}{2}$

(C) $j = \frac{5}{2}, \frac{7}{2}$ (D) $j = \frac{3}{2}, \frac{7}{2}$

161. If a system is such that the transition from eigenstate to another eigenstate is allowed then, the Hamiltonian must be

(A) Time dependent (B) Time independent

(C) Perturbation dependent (D) Perturbation independent

162. The validity of WKB (Wentzel-Kramers-Brillouin) approximation holds good when

(A) $\frac{m\hbar\left|\frac{\partial v}{\partial x}\right|}{[2m(E-V)]^{\frac{3}{2}}} < 1$ (B) $\frac{m\hbar\left|\frac{\partial v}{\partial x}\right|}{[2m(E-V)]^{\frac{3}{2}}} > 1$

(C) $\frac{m\hbar\left|\frac{\partial v}{\partial x}\right|}{[2m(E-V)]^{\frac{3}{2}}} \geq 1$ (D) $\frac{m\hbar\left|\frac{\partial v}{\partial x}\right|}{2m(E-V)^{\frac{3}{2}}} \geq 1$

163. Consider a system of N non-interacting particles (N >> 1) in which the energy of each particle can assume two and only two distinct values, 0 and E (E > 0). n_0 and n_1 denote the occupation numbers of energy level 0 and E respectively. The fixed total energy of system is U. Then the temperature as a function of U is (consider energy level to be non-degenerate)

(A) $\frac{NE-U}{U}$ (B) $-\frac{NE-U}{U}$

(C) $\frac{E}{k_B}\frac{1}{\log\frac{NE-U}{U}}$ (D) $-\frac{E}{k_B}\frac{1}{\log\frac{NE-U}{U}}$

164. A cylinder fitted with a piston contains ideal gas at 500 kPa and occupies a volume 0.2 m^3. If the gas expands isothermally to pressure 100 kPa, what is the work done by gas

(A) –160.9 J (B) 69.9 J

(C) –69.9 kJ (D) –160.9 kJ

165. A system of N particles at temperature T has two energy levels 0 and ε. The Helmholtz free energy of the system is

(A) $Nk_BT \ln \left(1+e^{\frac{-\varepsilon}{k_BT}}\right)$ (B) $k_BT \ln \left(1+e^{\frac{\varepsilon}{k_BT}}\right)$

(C) $-k_BT \ln \left(1+e^{\frac{-\varepsilon}{k_BT}}\right)$ (D) $-Nk_BT \ln \left(1+e^{\frac{-\varepsilon}{k_BT}}\right)$

166. If a system is in equilibrium with temperature T, pressure P, entropy S and volume V then the variation of pressure with temperature at constant volume $\left(\frac{\partial P}{\partial T}\right)_V$ is given by

(A) $\left(\frac{\partial T}{\partial V}\right)_P$ (B) $\left(\frac{\partial V}{\partial T}\right)_P$

(C) $-\left(\frac{\partial S}{\partial T}\right)_P$ (D) $\left(\frac{\partial S}{\partial V}\right)_T$

167. A body of constant heat capacity C_P and a temperature T_1 is brought into contact with a reservoir at temperature T_2. If the equilibrium between body and reservoir is established at constant pressure and $T_1 \neq T_2$, the total entropy change of the body plus the reservoir is

(A) $C_P\left(\frac{T_1 - T_2}{T_2}\right)$ (B) $C_P\left[\ln \frac{T_1}{T_2} - 1 + \frac{T_1}{T_2}\right]$

(C) $C_P \ln \frac{T_1}{T_2}$ (D) $C_P\left[\frac{T_1}{T_2} - \ln \frac{T_1}{T_2}\right]$

168. Consider a system of N weakly interacting particles, each of spin-$\frac{1}{2}$ and magnetic moment μ, exposed to an external magnetic field B. If system is in thermal contact with a heat reservoir at temperature T, then total magnetic moment of system is

(A) $N\mu \tanh\left(\frac{\mu B}{k_B T}\right)$ (B) $N\mu \coth\left(\frac{\mu B}{k_B T}\right)$

(C) $N\mu \sinh\left(\frac{\mu B}{k_B T}\right)$ (D) $N\mu \tanh^{-1}\left(\frac{\mu B}{k_B T}\right)$

169. A harmonic oscillator with energy level $E=\left(n+\frac{1}{2}\right)\hbar\omega$ is in thermal contact with a heat bath at temperature T. What is the ratio of probability of the oscillator being in the first excited state to the probability of its being in ground state?

(A) $\exp(-\hbar\omega / k_B T)$ (B) $\exp(-2\hbar\omega / k_B T)$

(C) $\exp(-\hbar\omega / 2k_B T)$ (D) $\frac{1}{2}$

170. The equation of state of a 3-dimensional ideal Fermi gas is given by $P = \frac{2}{5}\epsilon_F \tilde{n}\left[1+\frac{5c}{12}\pi^2\left(\frac{k_B T}{\epsilon_F}\right)^2\right]$; where P is pressure, T is temperature, $\tilde{n}$ is the number density of particles, ε_F is Fermi energy and C is a constant. Then the specific heat per particle at constant volume is given by

(A) $\frac{3C}{2}$

(B) $k_B \frac{\pi^2 C}{2}\left(\frac{k_B T}{\epsilon_F}\right)$

(C) $k_B \frac{\pi^2}{2}\left(\frac{k_B T}{\epsilon_F}\right)$

(D) $\frac{3k_B C}{2}\left(\frac{k_B T}{\epsilon_F}\right)$

171. A solid contain N magnetic ions having spin-$\frac{1}{2}$. At sufficiently high temperature each spin is oriented completely random. At sufficiently low temperature all the spins oriented along the same direction (i.e. ferromagnetic). Let us approximate the heat capacity as a function of temperature T by $C(T) = \begin{cases} C_1\left(\frac{2T}{T_1}-1\right) & if\ \frac{T_1}{2} < T < T_1 \\ 0 & otherwise \end{cases}$

The maximum value of specific heat is

(A) $Nk_B \ln 2$

(B) $Nk_B T \ln 2$

(C) $Nk_B \frac{\ln 2}{1-\ln 2}$

(D) $Nk_B(1-\ln 2)$

172. Consider a photon gas enclosed in volume V and in thermal equilibrium at temperature T. The photon is a massless particle. What is the chemical potential of the gas.

(A) Infinity

(B) Zero

(C) $-\ln\left(\frac{V}{k_B T}\right)\exp\left(\frac{-E}{k_B T}\right)$

(D) None of the above

173. The entropy of an ideal Fermi gas is given by

(A) $S = -k_B \sum_i [n_i \ln(n_i) + (1+n_i)\ln(1+n_i)]$

(B) $S = -k_B \sum_i [n_i \ln(n_i) - (1+n_i)\ln(1+n_i)]$

(C) $S = -k_B \sum_i [n_i \ln(n_i) + (1-n_i)\ln(1-n_i)]$

(D) $S = -k_B \sum_i [n_i \ln(n_i) - (1+n_i)\ln(1+n_i)]$

174. If an unbiased coin is tossed for 100 times, what is the variance in resulting distribution?

(A) 25

(B) 10

(C) 50

(D) 12.5

175. The entropy of a magnetic system changes by an amount $\Delta S = -K\frac{H}{T^2}\Delta H$ (where K is a constant) if its temperature is held constant at T and the magnetic field changed from H to $H+\Delta H$. The magnetization M of such system is

(A) $M = K\left(\frac{H}{T}\right)^2$

(B) $M = K\left(\frac{H}{T}\right)$

(C) $M = K\left(\frac{T}{H}\right)$

(D) $M = K\left(\frac{H^2}{T}\right)$

176. An ideal Bose gas in d-dimensions obeys the dispersion relation $\varepsilon(\vec{k}) = Ak^S$, where A and s are constants. For Bose-Einstein condensation to occur, the occupancy of the excited states $Ne = C\int_0^\infty \frac{e^{(d-s)/s}}{e^{\beta(\varepsilon-\mu)}-1}d\varepsilon$, where C is a constant, should remain finite even for chemical potential $\mu = 0$. This can happen if

(A) $\frac{d}{s} < \frac{1}{4}$

(B) $\frac{d}{s} > 1$

(C) $\frac{1}{2} < \frac{d}{s} < 1$

(D) $\frac{1}{4} < \frac{d}{s} < \frac{1}{2}$

177. The specific heat per molecule of a gas of diatomic molecules at high temperature is

(A) 3 k_B

(B) 3.5 k_B

(C) 8 k_B

(D) 4.5 k_B

178. The partition function of a system of N Ising spin 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

(A) $-k_B T \ln \lambda_2$

(B) $-k_B T \ln \lambda_1$

(C) $-k_B T \ln(\lambda_1 \lambda_2)$

(D) $-k_B T \ln\left(\frac{\lambda_1}{\lambda_2}\right)$

179. The Hamiltonian of a system of non-interacting spin–$\frac{1}{2}$ particles is $H = -\mu_0 B \Sigma_i S_i^z$, where $S_i^z = \pm 1$ are the component of i^{th} spin along external applied field B at temperature T such that $e^{\mu_0/k_B T} = 2$, the specific heat is

(A) $\frac{16}{25}k_B(\ln 2)^2$

(B) $\frac{16}{25}k_B$

(C) $\frac{8}{25}k_B \ln 2$

(D) $k_B(\ln 2)^2$

180. At absolute zero temperature, an intrinsic semiconductor
(A) Has a large number of electron
(B) Has a large number of holes
(C) Behaves like an insulator
(D) Behaves like a metallic conductor

181. As temperature T increases, in n-type semiconductor, the Fermi energy EF
(A) Moves towards middle of forbidden energy gap
(B) Moves towards conduction band
(C) May or may not shift depending on concentration of donor atoms
(D) Does not vary

182. An Op-amp as a voltage follower has a voltage gain of
(A) Infinity
(B) Unity
(C) Zero
(D) Less than unity

183. When negative feedback is applied to an amplifier its voltage gain
(A) Is increased
(B) Is reduced
(C) Remains the same
(D) None of the above

184. Photo-electric emission current is proportional to
(A) frequency of incident light
(B) incident light flux
(C) work function of photo- cathode
(D) angle of incident of radiation

185. Solar cell is device which
(A) Photo current is generated by the low surface area of depletion region
(B) Photo current is generated by the high surface area of depletion region
(C) Open circuit voltage is the same of photo current
(D) Reverse bias is needed in addition to open circuit voltage

186. Which of the following gate has logic 1 output, when all its inputs are at logic 0
(A) a NAND or an EX-OR
(B) an OR or an EX-NOR
(C) an AND or an EX-OR
(D) a NOR or an EX-NOR

187. How many select lines required in a 16 to 1 multiplexer

(A) 3
(B) 4
(C) 5
(D) 6

188. The A/D converter whose conversion time is independent of the number of bits is

(A) Dual slope
(B) Counter type
(C) Parallel conversion
(D) Successive approximations

189. If the radius of the first orbit in Hydrogen atom is 0.05 nm, the radius of the first orbit in Helium atom is

(A) 1 nm
(B) 0.05nm
(C) 0.025 nm
(D) 0.51 nm

190. For an atom in state of $^2D_{3/2}$ the Lande-g-factor should be

(A) 1.20
(B) 1.33
(C) 1.75
(D) 2

191. Which of the following has the order of increasing energy

(A) $^1D_2$, $^3F_2$, $^3D_2$
(B) $^1D_2$, $^3D_2$, $^3F_2$
(C) $^3F_2$, $^3D_2$, $^1D_2$
(D) $^3D_2$, $^3F_2$, $^1D_2$

192. The degeneracy of the spectral term 3F is

(A) 21
(B) 15
(C) 9
(D) 7

193. The normal Zeeman effect is

(A) Observed only in atoms with an even number of electronics
(B) Observed only in atoms with an odd number of electronics
(C) A confirmation of space quantization
(D) Not a confirmation of space quantization

194. In a very strong magnetic field, the splitting of spectral line is called

(A) Stark effect
(B) Zeeman effect
(C) Raman Effect
(D) Paschen-Back effect

195. The longest wavelength present in the Balmer series of Hydrogen atom corresponding to line

(A) 656 nm
(B) 364 nm
(C) 729 nm
(D) 328 nm

196. In a ruby laser population inversion is achieved by applying

(A) Magnetic field
(B) Electrostatic field
(C) Both magnetic & electrostatic fields
(D) Optical pumping

197. Atoms with ½ nuclear spin cannot have

(A) Hyperfine structure
(B) Electric dipole interaction
(C) Fine structure
(D) None of the above

198. The vibrational frequency of a diamagnetic molecule of reduced mass and force constant k is given by

(A) $2\pi\sqrt{\frac{\mu}{k}}$
(B) $\frac{1}{2\pi}\sqrt{\frac{\mu}{k}}$
(C) $\frac{1}{2\pi}\sqrt{\frac{k}{\mu}}$
(D) $2\pi\sqrt{\frac{k}{\mu}}$

199. The rotational energy of diatomic molecule are

(A) Continuous
(B) Discrete and equispaced
(C) Discrete and but not equispaced
(D) Nothing can be said

200. A laser beam of wavelength 740 nm has coherence time 4×10^{-5}s. The coherence length is

(A) 12 km
(B) 10 km
(C) 6 km
(D) 1.2 km

201. The ESR frequency of a unpaired electron in magnetic field of 0.3 T is

(A) 397 MHz
(B) 4397 MHz
(C) 6397 MHz
(D) 8397 MHz