Week 6 Assignment 1

The due date for submitting this assignment has passed. Due on 2018-03-21, 23:59 IST.

Submitted assignment

1) For a $C{l_2}$ gas molecule with a nuclear spin of 2, how many nuclear spin Eigen functions do you expect and what will be the number of total nuclear spin functions?

- (a) 16 and 4
- (b) 4 and 16
- (c) 4 and 256
- (d) 256 and 4

No, the answer is incorrect.
Score: 0
Accepted Answers:
(b) 4 and 16

2) During the interchange of identical nuclei in a homonuclear diatomic molecule, total wave function $\psi$ can be written as $\psi_{\text{total}} = \psi_{\text{trans}} \psi_{\text{elec}} \psi_{\text{vib}} \psi_{\text{rot}}$. If there is an interchange of two nuclei through origin in a Bosonic particle (with a nuclear spin of I), from the following which statement is correct ($J = \text{rotational quantum number}$)?

- (a) $I(I+1)$ nuclear spin functions couple to $\psi_I$ with odd J and $(I+1)(2I+1)$ nuclear spin functions couple to $\psi_I$ with even J.
- (b) $I(I+1)$ nuclear spin functions couple to $\psi_I$ with odd J and $(I+1)(2I+1)$ nuclear spin functions couple to $\psi_I$ with odd J.
- (c) $(I+1)(2I+1)$ nuclear spin functions couple to $\psi_I$ with even J and $I(I+1)$ nuclear spin functions couple to $\psi_I$ with even J.
- (d) $I(I+1)$ nuclear spin functions couple to $\psi_I$ with even J and $(I+1)(2I+1)$ nuclear spin functions couple to $\psi_I$ with odd J.

No, the answer is incorrect.
Score: 0
Accepted Answers:
(a) $I(I+1)$ nuclear spin functions couple to $\psi_I$ with odd J and $(I+1)(2I+1)$ nuclear spin functions couple to $\psi_I$ with even J.

3) The moment of inertia of oxygen molecule is $1.937 \times 10^{-46} \text{kg m}^2$. What is the rotational partition function for oxygen at 300K?

- (a) 80
4) Chemical potential of an ideal gas is simplified to \( \mu = -k_B T \ln \left( \frac{q}{N} \right) \) (\( q = \) single particle partition function), under the consideration that –
- The single particle partition function depends on total number of particles (N).
- The contribution of single particle partition function at constant T and V is zero.
- The single particle partition function becomes dependent of N only at constant T and V.
- The single particle partition function is independent of N.

No, the answer is incorrect.
Score: 0
Accepted Answers:
(d) The single particle partition function is independent of N.

5) For a temperature of 300K and pressure of 1 atm, what is the value of absolute entropy per mole \( \left( \frac{S}{Nk_B} \right) \) of Ar gas? Assume ideal gas behaviour and neglect electronic contribution and given that the thermal de Broglie wavelength (\( \Lambda \)) of Ar is \( 1.60 \times 10^{-11} \) m.
- (a) 154.73 mol\(^{-1}\)
- (b) 160.01 mol\(^{-1}\)
- (c) 150.51 mol\(^{-1}\)
- (d) 165.55 mol\(^{-1}\)

No, the answer is incorrect.
Score: 0
Accepted Answers:
(a) 154.73 mol\(^{-1}\)

6) Chemical potential of an ideal gas system is given by the expression:
\[ \mu(T, p) = \mu_0(T) + k_B T \ln(p) \]
In this expression the first term \( \mu_0(T) \) depends on –
- T only.
- T and p.
- p and intrinsic properties of the system.
- T and intrinsic properties of the system.

No, the answer is incorrect.
Score: 0
Accepted Answers:
(d) T and intrinsic properties of the system.

7) What are the degrees of freedom that are present in a diatomic ideal gas, but not in a monoatomic ideal gas?
- (a) Rotational and electronic.
- (b) Electronic and nuclear.
- (c) Rotational and vibrational.
- (d) Nuclear and rotational.

No, the answer is incorrect.
Score: 0
Accepted Answers:
8) What is the rotational contribution to Helmholtz free energy for a diatomic ideal gas? 1 point

(a) $-Nk_B T \ln \left( \frac{T}{\sigma \theta_r} \right)$
(b) $Nk_B T \ln \left( \frac{T}{\sigma \theta_r} \right)$
(c) $Nk_B \ln \left( \frac{T}{\sigma \theta_r} \right)$
(d) $-Nk_B \ln \left( \frac{T}{\sigma \theta_r} \right)$

No, the answer is incorrect.
Score: 0
Accepted Answers:
(a) $-Nk_B T \ln \left( \frac{T}{\sigma \theta_r} \right)$

9) From Sackur-Tetrode equation what is the value of $\Delta S$ in case of mixing of two identical ideal gases under reversible isothermal condition? 1 point

(a) $2Nk_B \ln 2$
(b) $Nk_B \ln 2$
(c) $4Nk_B \ln 2$
(d) 0

No, the answer is incorrect.
Score: 0
Accepted Answers:
(d) 0

10) What is the vibrational partition function for a diatomic ideal gas molecule at a temperature $T$ 1 point when we consider the bond dissociation energy as $D_0$ and the vibrational temperature as $\theta_{vib}$?

(a) $\frac{\exp(\beta D_0)}{1 + \exp \left( \frac{\theta_{vib}}{T} \right)}$
(b) $\frac{\exp(-\beta D_0)}{1 - \exp \left( -\frac{\theta_{vib}}{T} \right)}$
(c) $\frac{\exp(-\beta D_0)}{1 - \exp \left( \frac{-\theta_{vib}}{T} \right)}$
(d) $\frac{1 + \exp \left( \frac{-\theta_{vib}}{T} \right)}{1 - \exp(\beta D_0)}$

No, the answer is incorrect.
Score: 0
Accepted Answers:
(b) $\frac{\exp(-\beta D_0)}{1 - \exp \left( -\frac{\theta_{vib}}{T} \right)}$