Tutorial-6, Statistical Mechanics & Others (Paper-203), January 20,2016

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Maximum Marks: 50

Q-1. Rewrite $Z(V,T,\mu)=\sum_{N=0}^{\infty}\lambda^N Z(N,V,T)$ in terms of population (n_k) of individual quantum states (ε_k) where $\lambda=e^{\mu/k_BT}$. Work out- $S=\sum_{N=0}^{\infty}\sum_{\{n_k\}}^{*}x_1^{n_1}x_2^{n_2}..\sim S=\prod_{K=1}^{2}(1+x_K+x_K^2..)$.

Q-2. Prove that $\overline{p}V=k_BT\ln(Z(V,T,\mu))$ of a grand-canonical ensemble. What are thermodynamic characteristic functions of different ensembles?

Q-3. Obtain quantum statistics of *Fermi-Dirac* ($'+'$) gas ($Z_{FD}(V,T,\mu)$) using Pauli's *Exclusion Principle* (Restricted occupancy). Give examples of some fermions.

Q-4. Obtain quantum statistics of *Bose-Einstein* (-) gas ($Z_{BE}(V,T,\mu)$) (Unrestricted occupancy). Give some examples of bosons.

Q-5. Find internal energy $(\overline{E})$ of *Fermi-* and *Bose-* gases.

Q-6. How is chemical potential (μ) of quantum gases modified at classical limits- $N/V\rightarrow 0$ and $T\rightarrow\infty$?

Q-7. Find $\overline{N}$, average occupancy of individual quantum states $(\overline{n}_k)$ and $p-V$ relations for *Fermi-Dirac* and *Bose-Einstein* gases.

Q-8. Obtain classical limits of $\overline{E}$ and $p-V$ for F-D and B-E gases.

Q-9. Discuss similarities and dissimilarities of photons and phonons.

Q-10. Find quantum statistics of a gas with *maximum occupancy 'm'*. (Gentile's theory)

Q-11. Why in rotational spectra, the ground state (J=0) is not mostly populated? Find J_{max} in terms of temperature (T) and rotational temperature constant (θ_r).

Q-12. What are the basic postulates of Einstein's theory of specific heat of monoatomic crystal? Compare C_v (Dulong and Petit's) in light of Einstein's theory of C_v for monoatomic crystal at high temperature (T).

Q-13. Predict C_v at $T\rightarrow 0$ by Einstein's theory on monoatomic crystal.

Q-14. Find equilibrium constant K_c in terms of partition functions of reactants and products. Obtain relation between K_p and K_c.

Q-15. What is the ratio of J_{max} of H_2, HD and D_2 in rotational spectra?

Books: McQuarrie (Statistical Mechanics), Callen (Thermodynamics and Thermostatistics), Nash (Elements of Statistical Thermodynamics), Atkins (Physical Chemistry), Landau &

Lifshitz (Statistical Physics),MC Gupta (Statistical Mechanics).