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MANIPAL UNIVERSITY, MANIPAL

FOURTH SEMESTER M.SC (PHYSICS) END SEMESTER EXAMINATION, MAY, 2016

SUB: THERMODYNAMICS AND STATISTICAL PHYSICS (PHY- 702)

TIME: 3 HRS. **MAX.MARKS : 50**

NOTE:(A) ANSWER ANY FIVE FULL QUESTIONS. (B) EACH QUESTION CARRIES 10 MARKS.

1A. Obtain the four, Maxwell's thermodynamic relations. **[7]**

1B. Obtain an expression for $C_P - C_V$, in terms of bulk modulus and coefficient of volume expansion. **[3]**

2A. Obtain the expressions for the work done by a van der Waals gas in a reversible isothermal expansion at temperature T, in terms of van der Waals constants, its initial and final volumes. Also obtain the expressions for the change in internal energy of the gas. **[5]**

2B. Calculate the volume element in the phase space for a harmonic oscillator, and obtain an expression for the number of quantum states in a volume element of the phase space. **[5]**

3A. State and prove Liouville's theorem. **[5]**

3B. Obtain an expression for the probability of distribution in the random walk problem. **[5]**

4A. State and prove the equipartition theorem. **[5]**

4B. A diatomic gas is in thermal equilibrium at temperature 500 K. Its rotational constant is B = 200/m. Compute the rotational populations (in terms of ground state population) in the rotational states: J = 0, 10, 20. The rotational energy is E = J(J+1) h c B. Speed of light in vacuum = 3.00×10^{8} m/s, Planck's constant = 6.63×10^{-34} J.s, Boltzmann constant = 1.38×10^{-23} J/K. **[5]**

5A. Obtain Planck's radiation law of blackbody radiation by quantum statistics of photon gas. Show its reduction to Rayleigh-Jeans law and Wien's law under various circumstances. **[5]**

5B. Discuss briefly the free electron theory of metals considering it as an ideal Fermi-gas. **[5]**

6A. Discuss Brownian motion as an example of fluctuating force using Fokker-Planck equation. **[5]**

6B. Setup the diffusion equation and solve it. Show that $\langle r^2(t) \rangle = 6\,D\,t$. **[5]**

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Useful formulae:

Stirling formula: $n! \cong (2\pi n)^{1/2} n^n e^{-n}$

$$\ell n(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \cdots \quad , \quad |x| < 1$$

$$e^x = \sum_o^\infty \frac{x^n}{n!}$$

$$\int_o^\infty x^r e^{-nx} \, dx = \frac{r!}{n^{r+1}}$$

$$\int_o^\infty x^4 \, exp\,(-ax^2) \, dx = \frac{3}{8a^2}\sqrt{\frac{\pi}{a}}$$

$$\int_o^\infty x^2 \, exp\,(-ax^2) \, dx = \frac{1}{4a}\sqrt{\frac{\pi}{a}}$$

$$\int_o^\infty \frac{x^{n+1}}{e^x - 1} \, dx = \Gamma(n)\,\zeta(n)$$

$\Gamma(n+1) = n!$ if n is an integer

$\Gamma(n+1) = n(n-1) \cdots \frac{3}{2} \cdot \frac{1}{2} \cdot \sqrt{\pi}$ if n is half integral

$$\zeta(4) = \frac{\pi^4}{90}$$

$$\zeta\left(\frac{5}{2}\right) = 1.341$$

$$\zeta\left(\frac{3}{2}\right) = 2.612$$

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