5M/PHY-302 Syllabus-2023

2025

(Nov–Dec)

FYUP : 5th Semester Examination

MAJOR

PHYSICS

(Thermal and Statistical Physics)

PHY-302

Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer *any* **ten** questions

1. Derive the general expression for Maxwell's thermodynamical relations and hence derive the four Maxwell's thermodynamic relations. 5½+2=7½

2. What is Joule-Thomson cooling? Deduce the thermodynamic expression for the Joule-Thomson coefficient, μ. Prove that for a perfect gas, $\mu = 0$. 1+4½+2=7½

3. *(a)* Prove the following thermodynamic relation : 2½

$$C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$$

(b) Derive the first and second T*ds* equations. 2½+2½=5

4. *(a)* Deduce Clapeyron's latent heat equation using Maxwell's thermodynamic relations. Discuss briefly the effect of change in pressure on boiling point. 3½+1=4½

(b) Calculate under what pressure ice freezes at 272 K if the change in specific volume, when 1 kg of water freezes, is 91×10^{-6} m^3. Given, latent heat of ice = $3{\cdot}36 \times 10^5$ J-kg^{-1}. 3

5. *(a)* What is Gaussian distribution? Obtain the expression for it. 1+5=6

(b) Find the probability density function for the normal distribution where mean =4, standard deviation = 2 and random variable, $x = 3$. 1½

6. *(a)* Derive Stirling's approximation

$$\ln(n!) = n\ln n - n$$ 3½

(b) A bag contains 7 red, 8 yellow and 5 green balls. The balls are drawn at random from the bag. What is the probability of selecting *(i)* red ball and *(ii)* yellow ball? 2+2=4

7. *(a)* Explain the terms 'phase space' and 'momentum space'. 1+1=2

(b) Calculate the number of phase cells, and hence energy, in the energy range 0 to E for a linear harmonic oscillator of mass m and frequency ν. 5½

8. Establish Liouville's theorem and explain its physical significance. 6+1½=7½

9. Define entropy. Deduce Boltzmann's entropy probability relation $S = k_B \ln W$, where symbols carry their usual meaning. 1½+6=7½

10. What is canonical ensemble? Obtain the expression for the probability distribution function in a canonical ensemble. 1½+6=7½

11. State and prove the law of equipartition of energy. 1½+6=7½

12. *(a)* What is partition function? Mention its importance and write down its relation with entropy of a thermodynamic system. 1½+1½+1½=4½

(b) At what temperature will the average speed of molecules of hydrogen gas be doubled the average speed of molecules of oxygen at 300 K? 3

13. (a) Using Maxwell-Boltzmann distribution function, find the total internal energy and specific heat at constant volume of a perfect gas. 4½

(b) For O_2 gas at NTP, calculate *(i)* most probable speed and *(ii)* root mean square speed.
Given, Boltzmann's constant, $k_B = 1 \cdot 38 \times 10^{-23}$ JK^{-1} and Avogadro's number, $N_A = 6 \cdot 02 \times 10^{23}$/mole. 1½+1½=3

14. What are the basic postulates of Fermi-Dirac statistics? Derive an expression for probability distribution of particles governed by Fermi-Dirac statistics. 1½+6=7½

15. Write down the expression for Bose-Einstein distribution function. Apply Bose-Einstein statistics to deduce Planck's radiation law in terms of wavelength. 1+6½=7½

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