

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.
 $5\frac{1}{2}+2=7\frac{1}{2}$
2. What is Joule-Thomson cooling? Deduce the thermodynamic expression for the Joule-Thomson coefficient, μ . Prove that for a perfect gas, $\mu = 0$.
 $1+4\frac{1}{2}+2=7\frac{1}{2}$

26D/775

(Turn Over)

(2)

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 Tds 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 $91 \times 10^{-6} \text{ m}^3$. Given, latent heat of ice = $3.36 \times 10^5 \text{ J}\cdot\text{kg}^{-1}$. 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

$$\ln(n!) = n \ln n - n \quad \text{3½}$$

(3)

- (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 . $5\frac{1}{2}$
8. Establish Liouville's theorem and explain its physical significance. $6+1\frac{1}{2}=7\frac{1}{2}$
9. Define entropy. Deduce Boltzmann's entropy probability relation $S = k_B \ln W$, where symbols carry their usual meaning. $1\frac{1}{2}+6=7\frac{1}{2}$
10. What is canonical ensemble? Obtain the expression for the probability distribution function in a canonical ensemble. $1\frac{1}{2}+6=7\frac{1}{2}$
11. State and prove the law of equipartition of energy. $1\frac{1}{2}+6=7\frac{1}{2}$
12. (a) What is partition function? Mention its importance and write down its relation with entropy of a thermodynamic system. $1\frac{1}{2}+1\frac{1}{2}+1\frac{1}{2}=4\frac{1}{2}$

- (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. $4\frac{1}{2}$
- (b) For O_2 gas at NTP, calculate (i) most probable speed and (ii) root mean square speed.
Given, Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$ and Avogadro's number, $N_A = 6.02 \times 10^{23} / \text{mole}$. $1\frac{1}{2} + 1\frac{1}{2} = 3$
14. What are the basic postulates of Fermi-Dirac statistics? Derive an expression for probability distribution of particles governed by Fermi-Dirac statistics. $1\frac{1}{2} + 6 = 7\frac{1}{2}$
15. Write down the expression for Bose-Einstein distribution function. Apply Bose-Einstein statistics to deduce Planck's radiation law in terms of wavelength. $1 + 6\frac{1}{2} = 7\frac{1}{2}$
