U.G. 4th Semester Examination-2026

PHYSICS

[MAJOR-V]

Course Code : PHY-M-T-5

(Thermal Physics)

[NEP-2020]

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

1. Answer any **five** questions: 2×5=10

   a) Sketch the Carnot cycle for an ideal gas on (i) T-S diagram and (ii) T-V diagram.

   b) Write down the Helmholtz free energy and corresponding Maxwell equation.

   c) Write down an *equation of isobar* of an ideal gas and sketch the *V-T diagram* at low and high pressure cases.

   d) What do you mean *degrees of freedom* of a dynamical system? If the degrees of freedom of a gas molecules is **n** find the ratio of two specific heat.

   e) What is Brownian motion? Give the essential features of the motion.

   f) At what temperature, the r.m.s. speed is twice the r.m.s. speed at 27°C of oxygen molecule.

g) A carnot engine operate between the ice point and stream point. If the engine recieves 746 calories from the source in each cycle, how many calories does it reject to the sink?

h) What is the difference between the *gas* and the *vapour* of a same substance?

2. Answer any **two** questions: 5×2=10

a) What do you mean by *mean free path* of a molecule in a gas assembly? Derive the Claussius expression for mean free path. 1+4

b) Write down the expression for the coefficient of viscosity and the thermal conductivity and find the relation between them. Find the coefficient of velocity thermal conductivity and diffusion coefficient for air. Given $\rho = 1.29\ Kg\text{-}m^{-3}$, $\bar{c} = 460\ ms^{-1}$, $\lambda = 6.4\times10^{-8}\ m$ and specific heat at constant volume $c_v = 10^4\ J/Kg/deg$. 2+3

c) What do you mean by *quasistatic process* — explain it. From the 1st law of thermodynamics derive the relation $C_p - C_v = \left\{p + \left(\frac{\partial U}{\partial V}\right)_T\right\}\beta V$. 2+3

d) State the Kelvin-Planck and Clausius statements of the second law of thermodynamics. Two Carnot's engines A and B operate in series. A receives heat at 900°K and rejects to a reservoir at temperature T°K. B receives the heat rejected by A and in turn rejects to a reservoir at 400°K. Find the temperature T when the work output of A and B are equal. Also calculate the temperature T when the efficiency of A and B are equal. 2+3

3. Answer any **two** questions: 10×2=20

a) i) Write down the Maxwell's velocity distribution law of the molecules of a gas and explain the symbol you use. Hence calculate the r.m.s. velocity of the molecule. 2+3

ii) Derive the Maxwell's energy distribution from the velocity distribution law of the molecules. Two ideal monoatomic gases of temperatures T_1 and T_2 are mixed with no loss of energy. If the masses and number of molecules of the two gases be m_1, m_2 and n_1, n_2 respectively they show that the temperature of the mixture is

$$T = \frac{n_1T_1 + n_2T_2}{n_1 + n_2}.$$ 2+3

b) i) Explain the concept of entropy. Show that the entropy of a system is path independent for any reversible process. 2+3

ii) Show that entropy of n mole of an ideal gas of constant heat capacity C_V at a temperature T and volume V is given by $S = C_V InT + n\,RInV + S_0$. 3

iii) Calculate the change in entropy when 1 gm-atom of solid tin(Sn) at its melting point (232°C) is raised to a temperature of 272°C. [atomic wt. of tin = 118, latent heat of fusion = 14 cal/gm mean specific heat over temperature change = 0.064]. 2

c) i) Explain the working principle of a Carnot cycle as a refrigerator and obtain an expression for the coefficient of performance. 2+3

ii) What do you mean by 1st order and 2nd order phase transition? 2

iii) 3 mole of a gas at 0°C is compressed isothermally from volume 10 litres to 2.5 litres. Calculate the work done [R = 8.32 J/mol/K]. 3

d) i) Define the critical temperature, critical pressure and critical volume. Calculate the critical constants of van der Waal's gas. 3+3

ii) Calculate the van der Waal's constants a and b and also calculate the diameter of a molecule of Helium gas. Assume that co-volume b is four times the volume occupied by the molecule. [Tc = 5.3 K, pc = 2.25 atmos, R = 8.32 J/mol/K and 1 atmos $=1.013\times10^{5}Nm^{-2}$]. 4
