U.G. 4th Semester Examination-2025

PHYSICS

[MAJOR]

Course Code : PHY-MJ-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.

Symbols have their usual meaning.

1. Answer any **five** questions: $2\times5=10$

   a) What do you mean by thermodynamics equilibrium? How many types of such equilibrium are there and explain them?

   b) Define intensive and extensive variables with examples.

   c) Write down the first law of thermodynamics for a closed system and explain it.

   d) What do you mean by entropy of a system?

   e) Write down the four Maxwell's equation.

   f) Define the volume expansivity and isothermal compressibility?

[Turn over]

g) Calculate work done in compressing an ideal gas of 2 mol from volume 4 litre to 1 litre at a contstant temperature 20°C.

h) Write down the law of equipartition of energy. What will be the total energy of a diatomic gas molecule?

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

a) Prove the relation $C_p - C_v = -T\left(\frac{\partial V}{\partial T}\right)_p^2\left(\frac{\partial p}{\partial V}\right)_T$.

From this relation, show that $C_p - C_v = nR$ for the ideal gas (assume the ideal gas equation of state). 3+2

b) State the Clausius's theorem. Show that for any reversible process, change of entropy is independent of path. 2+3

c) Consider entropy of a pure substance as a function of two variables, pressure p and volume V. Show that the change in entropy is given by

$$dS = \frac{1}{T}\left[C_v\left(\frac{\partial T}{\partial p}\right)_v dp + C_p\left(\frac{\partial T}{\partial V}\right)_p dV\right].$$ 5

d) Consider the Gibb's potential $G = H - T.S.$ Show that this potential holds the exact differential equation. 5

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

a) i) Explain the Carnot's heat engine with phase diagram and calculate its efficiency. 5

ii) A cyclic heat engine operates between a source temperature of 800°C and a sink of temperature 30°C. Calculate the efficiency of the heat engine. What is the least rate of heat rejection in 2 kW net output of the engine? 2+3

b) i) Derive the Clausius-Clapeyron equation.

ii) The vapour pressure of solid ammonia is $\ln p = 23.03 = \frac{3754}{T}$ and that of liquid ammonia by $\ln p = 19.49 - \frac{3063}{T}$ (measured in mm of mercury). What is the temperature and pressure at the tripple point. Assuming that the molar volume of vapour ammonia is greater than that of liquid ammonia, calculate the latent heat of vaporization of ammonia (ideal gas constant R = 8.3143 J/(mol.K)). 5+3+2

c) Derive the Maxwell-Boltzman velocity distribution for ideal gas. Assuming kinetic energy of gas molecule, deduce the Maxwell-Boltzman energy distribution. Calculate the root-mean-square velocity of helium at 0°C ($K = 1.38 \times 10^{-16}$ erg/K). 6+2+2

d) i) What is Joule-Thompson coefficient and derive the expression for it. Why is it zero for an ideal gas?

ii) For van der Waal's gas $\left(p+\frac{a}{v^2}\right)(v-b)=RT$ show that, the Joule-Thompson coefficient is $\mu_j = \frac{v}{C_p}\left[\frac{2a(v-b)^2 - RTbv^2}{RTv^3 - 2a(v-b)^2}\right]$.

(1+5+1)+3