FYUG Odd Semester Exam., 2025

PHYSICS

(3rd Semester)

Course No. : PHYDSC–202T

(Thermal Physics)

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

UNIT—I

Answer any *two* of the following questions : 2×2=4

(a) State zeroth law and first law of thermodynamics.

(b) What is meant by thermodynamic work?

(c) Define the term source and sink in the context of second law of thermodynamics.

2. Answer *either* [*(a)* and *(b)*] or [*(c)* and *(d)*] :

(a) What is internal energy? Prove that for an isolated system, there is no change in the internal energy.

(b) Using first law of thermodynamics, show that $C_P - C_V = L\beta V$ where

$$\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P \text{ and } L = \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right]$$

(c) Define coefficient of performance. Why the performance of refrigerator and heat pump are given in terms of coefficient of performance and not in terms of efficiency?

(d) State Kelvin-Planck and Clausius statements of second law of thermodynamics. Explain the equivalence of both the statements in detail.

UNIT—II

Answer any *two* of the following questions :

(a) What is meant by principle of increase of entropy?

(b) Entropy of universe can never decrease. Justify the statement.

(c) Prove that

$$G = H + T\left(\frac{\partial G}{\partial T}\right)_P$$

4. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] : 10

(a) Explain the physical significance of entropy in detail. 4

(b) Find the expression of change of entropy for an ideal gas in terms of pressure and volume. 6

(c) State third law of thermodynamics. Explain the concept of unattainability of absolute temperature. 1+3=4

(d) Explain the temperature entropy diagram for Carnot's cycle in detail. 6

UNIT—III

5. Answer any *two* of the following questions : 2×2=4

(a) Define phase and phase transition.

(b) Write four Maxwell's thermodynamical relations.

(c) Show that adiabatic compression always results in increase of temperature.

(Turn Over)

(a) What is Brownian motion? Explain.

(b) How does viscosity of a liquid change with temperature and why does it change like that?

4. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] : 10

(a) What is phase space? Show that the number of phase space cells in the momentum range p to $p+dp$ is

$$\frac{4\pi VP^2 dp}{h^3}$$

where the symbols have their own meaning. 1+4=5

(b) Find an expression for average speed of molecules in Maxwell-Boltzmann distribution.

(c) Using kinetic theory, find the expression of thermal conductivity as $k = \frac{1}{3}\rho \bar{c} \lambda C_V$, where ρ represents density, $\bar{c}$ represents average molecular speed, λ represents mean free path and C_V represents specific heat capacity.

(d) Obtain the expression of diffusion coefficient as $D = \frac{1}{3}c\lambda$ where c represents concentration and λ represents mean free path.

(Turn Over)

(c) Deduce Clausius-Clapeyron equation using Maxwell's relation.

(b) Using Maxwell's thermodynamic relations, prove that

$$C_P - C_V = -T\left(\frac{\partial V}{\partial T}\right)^2 \left(\frac{\partial P}{\partial V}\right)_T$$

From the above equation show that $C_P > C_V$. 5+2=7

(c) Prove that

$$\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$$

and

$$\left(\frac{\partial C_V}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$$

(d) Deduce Clausius-Clapeyron equation for a first-order phase transition. 7

UNIT—IV

7. Answer any *two* of the following questions : 2×2=4

(a) State any two assumptions of kinetic theory of gases.

(Continued)

UNIT—V

9. Answer any *two* of the following questions : 2×2

(a) Why does real gases deviate from ideal behaviour?

(b) State some drawbacks of van der Waals' equation.

(c) Why do some gases heat up and others cool down when expanded through a porous plug?

10. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] :

(a) Define critical temperature, critical pressure and critical volume of real gases.

(b) Describe Andrews' experiment and comment on its experimental findings.

(c) Explain positive and negative Joule-Thomson effects.

(d) Show that the Joule-Thomson coefficient can be expressed as

$$\mu\,(J\text{-}T \text{ effect}) = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$$

where symbols have their own meanings.

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