TDC (CBCS) Odd Semester Exam., 2020
held in March, 2021

PHYSICS

(3rd Semester)

Course No. : PHSHCC-302T

(Thermal Physics)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

1. Answer any *ten* of the following questions : 2×10=20

(a) The conduction of heat from a hot body to cold body is reversible or irreversible process. Explain.

(b) What is meant by thermodynamic equilibrium?

(c) Distinguish between isothermal and adiabatic processes.

(d) Why is C_P greater than C_V?

(e) What happens to change in entropy of a system which undergoes (i) a reversible process and (ii) an irreversible process?

(f) Explain in brief the concept of 'heat death of the universe'.

(g) State the significance of thermodynamic potentials.

(h) Name the processes, the Carnot engine undergoes during its complete cycle.

(i) Does boiling point of a liquid remain constant at all pressure? Explain.

(j) Why does a rubber string heat up on stretching?

(k) Write four Maxwell's thermodynamic relations.

(l) What do you mean by first-order phase transition?

(m) What is the effect of temperature and pressure on thermal conductivity?

(n) Define free path and mean free path.

(o) Define degrees of freedom and law of equipartition energy.

(p) Define and explain transport phenomenon.

(q) In what way a real gas differs from an ideal gas?

(r) Mention the limitation of van der Waals' equation.

(s) Distinguish between adiabatic expansion and Joule-Thomson effect.

(t) Define critical constant.

SECTION—B

Answer *any* **five** questions

2. (a) What is internal energy of a system? "Internal energy is state function and not a path function." Explain. 3

(b) Show that the work done in adiabatic expansion of an ideal gas from a state (P_1, V_1) to a state (P_2, V_2) is given by

$$W = \frac{1}{\gamma - 1}[P_1V_1 - P_2V_2]$$ 3

3. *(a)* A Carnot engine has an efficiency of 30% when the temperature of the sink is 27 °C. What must be the change in temperature of the source to make its efficiency 50%? 3

(b) Explain thermodynamic scale of temperature and show that the thermodynamic and the ideal gas scale are identical. 3

4. *(a)* Prove that for a complete reversible cycle change in the state of substance $\oint dS = 0$. 3

(b) Explain the concept of entropy and disorder. 3

5. *(a)* Establish the relation for efficiency of a Carnot's engine using T-s diagram in

$$\eta = \frac{T_1 - T_2}{T_1}$$ 3

(b) Define the Helmholtz function and for an isochoric process, establish the relation

$$U = F - T\left(\frac{\partial F}{\partial T}\right)_V$$ 3

6. *(a)* Using Maxwell's thermodynamic relations, prove that for any substance, the ratio of the adiabatic and isothermal elasticities is equal to the ratio of the two specific heats. 3

(b) Taking into consideration of Maxwell's thermodynamical relations, show that

$$C_P - C_V = TE\alpha^2 V$$

where T is the absolute temperature, E is the modulus of isothermal elasticity, α is the coefficient of volume and V is the specific volume. 3

7. *(a)* Discuss about second-order phase transition and hence derive Ehrenfest's theorem. 3

(b) Prove the following thermodynamic relations : 1½×2=3

(i) $TdS = C_V dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$

(ii) $TdS = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$

8. *(a)* Assuming M-B distribution of molecular speeds, show that the most probable speed is given by

$$v_{mp} = \sqrt{\frac{2kT}{m}}$$ 3

(b) Calculate the Doppler broadening in hydrogen line 4861 Å for $T = 400k$. Given $k = 1 \cdot 380 \times 10^{-16}$ erg per degree. 3

9. *(a)* Obtain Maxwell's expression for mean free path

$$\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 n}$$

where σ is the molecular diameter and n is the number of molecules per unit volume on the basis of kinetic theory of gases. 3

(b) Derive the relation for coefficient of self-diffusion D and show that it is directly proportional to $T^{3/2}$. 3

10. *(a)* What do you understand by virial coefficients? What is the value of first virial coefficient? How does the second virial coefficient vary with temperature? 3

(b) Define critical coefficient of a gas. Is it same for all gases? Does experimental value agree with the theoretical value? 3

(Continued)

11. *(a)* What is Joule-Thomson effect? How will you interpret the effect experimentally? 3

(b) Define temperature of inversion. Derive the expression for the inversion temperature for van der Waals' gas

$$T_i = \frac{2a}{R_b}$$ 3

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