2020

PHYSICS

[HONOURS]

Paper : IV

[SUPPLEMENTARY]

Full Marks : 75 Time : 4 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.

Specify all symbols in your answer.

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

   a) What do you mean by equipartition of energy?

   b) State the behaviour of Gibb's function (G) and entropy (S) during first order phase transition.

   c) What is the condition for which a reversible heat engine can have 100% efficiency? Give reason of your answer.

   d) What is the basic principle of resistance thermometer?

   e) What type of thermometer can be used for measuring the temperature of sun? Why?

   f) What is virial coefficient?

   g) Define emissive power for a monochromatic radiation.

2. Answer any **six** questions: 2×6=12

   a) Why the internal energy of a Van der Waal's gas is not independent of volume?

   b) Explain the Helmholtz function F, and show that F remains constant during isothermal process.

   c) What do you mean by critical temperature, critical pressure and critical volume of a gas?

   d) A system evolves in such a direction that would cause an increase in entropy of the universe — Justify.

   e) What is the value of the thermal expansion co-efficient when the Helmholtz function F is independent of volume?

   f) Show that the Helmholtz function

$$F = -T\int \frac{U}{T^2}\, dT .$$

   g) Define Boyle temperature. Show that $T_B \simeq \frac{a}{Rb}$, symbols have their usual meaning.

h) Justify that the average thermal energy for each degrees of freedom is $\frac{1}{2}kT$.

i) State the principle of resistant thermometer and thermoelectric thermometer.

j) Find the law of distribution of free paths, assume λ is the mean free path.

3. Answer any **three** questions: 6×3=18

a) A van der Waal's gas has the equation of state $\left(p+\frac{a}{V^2}\right)(V-b)=KT$.

i) Discuss the physical origin of the parameter a and b.

ii) The gas undergoes an isothermal expansion from volume V_1 to volume V_2. Calculate the change in the Helmholtz free energy.

iii) Calculate the change in the internal energy. 2+2+2

b) State all the steps of Otto cycle with the help of PV diagram. Hence calculate the efficiency of Otto cycle. 2+4

c) Derive Gibbs-Helmholtz equation from Gibbs free energy equation. Define the Joule-Thompson coefficient. Why its value is zero for an ideal gas at all temperature? 4+2

d) Calculate the average value of v_x in Maxwellian distribution. State and explain Le-Chatelier principle on chemical equilibrium. 3+3

e) Show that the number of molecule dN_E with translational kinetic energy btween E and E+dE is given by $dN_E=\frac{2N}{(KT)^{\frac{3}{2}}}\left(\frac{E}{A}\right)^{\frac{1}{2}}e^{-\frac{E}{kT}}dE$. 6

4. Answer any **four** questions: 10×4=40

a) State and prove the Carnot theorem. Find the change in temperature ΔT in a sudden expansion of a system in terms of C_p, α etc. Establish $S=C_u\log T+R\log(V-b)+\text{const}$. 4+3+3

b) Explain the principle of cooling of a system by adiabatic demagnetization. Derive Clapeyron's equation, hence find the dependence of the saturated vapour pressure on the temperature. 4+3+3

c) Show that for Van der Waal's gas

$$C_p - C_v \cong R\left(1+\frac{2a}{RTV}\right).$$

Find the entropy of diffuse radiation at equilibrium at temperature T. State and explain the chemical equilibrium of gases system. What is the significance of equilibrium constants? 4+3+3

d) Estimate the mean square of the displacement of the Brownian particle in terms of temperature etc. of the gas starting from basic principle. State the utility of the relation. Derive the law of corresponding states in terms of critical qualities T_c, p_c, V_c from Van der Waal's equation of state. 5+1+4

e) Evaluate the distribution of energy among the molecules from the Maxwell's distribution. What do you mean by the equipartition of energy? Estimate the relation between the ratios of the specific heats with the degrees of freedom. State Dulong and Petits law. State the domain of validity of the Dulong and Petits law. 4+2+2+2

f) Establish the relationship between the radiation pressure and energy density of a diffuse radiation. How do you estimate the temperature of the Sun using the basic law of radiation? Deduce Newton's law of cooling from the radiation law. 5+3+2