2012

PHYSICS

(Major)

Paper : 2.2

Full Marks : 60

Time : 2½ hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option/Answer the following : 1×7=7

(a) According to the kinetic theory of gases, the r.m.s. speed of gas molecules is directly proportional to

(i) T

(ii) $\sqrt{T}$

(iii) T^2

(iv) $\frac{1}{\sqrt{T}}$

(b) What is meant by 'mean free path' of molecules in a gas? Write down Clausius expression for it.

(c) The Boyle temperature T_B for a van der Waals' gas is given by

(i) $T_B = \frac{8a}{27Rb}$

(ii) $T_B = \frac{a}{Rb}$

(iii) $T_B = \frac{2a}{Rb}$

(iv) $T_B = \frac{27}{8} T_C$

(d) Distinguish between thermal conductivity and thermometric conductivity.

(e) The first law of thermodynamics is a restatement of law of conservation of

(i) mass

(ii) momentum

(iii) energy

(iv) None of the above

(f) Which is the more effective way to increase the efficiency of a Carnot engine : to increase the source temperature T_1 or to lower the sink temperature T_2?

(g) State Stefan-Boltzmann law.

2. Answer the following questions : 2×4=8

(a) Calculate the magnitude of mean free path and the collision frequency for air molecules at 0 °C and 1 atm pressure.

(b) Show that at the critical temperature, the departure of the van der Waals' gas law from the ideal gas law $p_c V_c / T_c = R$ measures 62·5%.

(c) 20 g of hydrogen gas at 27 °C is compressed isothermally to one-fourth of the original volume. Find the value of the work done.

(d) Give the Gibbs-Helmholtz equation for a reversible cell. What is its significance? When is the reaction endothermic and exothermic?

3. Answer any *three* of the following questions : 5×3=15

(a) Establish that associated energy per degree of freedom is $\frac{1}{2}\ kT$.

(b) Starting from Planck's radiation formula, obtain Rayleigh-Jeans law. Explain the limitation of Rayleigh-Jeans law.

(c) Show that $\eta = \frac{1}{3}\rho \bar{c} \lambda$, where η is the viscosity of the gas, ρ the density, $\bar{c}$ the mean molecular velocity and λ the mean free path.

(d) Write a short note on adiabatic demagnetisation.

(e) If $H = U + pv$ represents enthalpy of a system containing gas, prove that

$$C_P - C_V = p\left(\frac{\delta V}{\delta T}\right)_P + \left(\frac{\delta U}{\delta V}\right)_T \left(\frac{\delta V}{\delta T}\right)_p$$

4. (a) Obtain the Kelvin's thermodynamical scale of temperature. 10

Or

Show that enthalpy remains constant in Joule-Thomson effect.

(b) Deduce the expression for pressure of a confined gas on the basis of kinetic theory of gases using spherical polar coordinates. 10

Or

Deduce Planck's law of black-body radiation and obtain Stefan's law from Planck's law.

(c) Relating to Joule-Thomson effect, obtain the relation

$$\mu C_P = -\left[\frac{\delta U}{\delta P}\right]_T + \left[-\frac{\delta}{\delta P}(PV)_T\right]$$

where μ is the Joule-Thomson coefficient $\left[\mu = \left(\frac{\delta T}{\delta P}\right)_H\right]$. 10

Or

Derive the relations

(i) $\left(\frac{\delta s}{\delta V}\right)_T = \left(\frac{\delta p}{\delta T}\right)_V$

(ii) $\left(\frac{\delta p}{\delta T}\right)_{sat} = \frac{L}{T(V_2 - V_1)}$

where the symbols have their usual meanings. 5+5=10

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