

2012

PHYSICS

(Major)

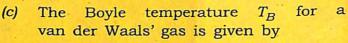
Paper: 2.2

Full Marks: 60

Time: 21/2 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) T²
 - (iv) $\frac{1}{\sqrt{T}}$
 - (b) What is meant by 'mean free path' of molecules in a gas? Write down Clausius expression for it.



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

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

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

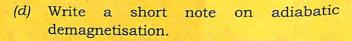
(iv)
$$T_B = \frac{27}{8}T_C$$

- (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:

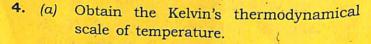
 $2 \times 4 = 8$

- (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 $p_cV_c / T_c = R$ 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: $5 \times 3 = 15$
 - (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.



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

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



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

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