2013

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) Why does the pressure of a gas on the container wall increase, when it is heated?
 - (b) A jar A is filled with a gas characterised by (p, V, T). Another jar B is filled with a gas with parameters (2p, V/4, 2T). The ratio of the number of molecules in jar A to those in jar B is
 - (i) 1:1
 - (ii) 1:2
 - (iii) 2:1
 - (iv) 4:1

- The value of the critical volume V_c according to van der Waals equation is
 - (i) $V_c = 2b$
 - (ii) $V_c = b$
 - (iii) $V_c = 2.5b$
 - (iv) None of the above
- (d) With usual meanings of the symbols, the Einstein's equation for Brownian motion is given by

(i)
$$\Delta^2 = \frac{RT}{N_A} \frac{1}{3\pi \eta r} J$$

(ii)
$$\Delta^2 = \frac{KT}{3\pi\eta r N_A}$$
 J

(iii)
$$\Delta^2 = \frac{KT}{3\pi\eta Rr}$$
 J

- (iv) None of the above
- (e) The value of y for an ideal monatomic gas is
 - (i) $\frac{3}{2}$
 - $(ii) \quad \frac{5}{2}$ $(iii) \quad \frac{3}{5}$ $(iv) \quad \frac{5}{3}$

- (f) Elaborate the essential difference between the first law and the second law of thermodynamics.
- (g) What do you mean by 'lagged' bar? Is there any radiation loss in such a bar?
- **2.** Answer the following questions: $2 \times 4 = 8$
 - (a) The density of hydrogen at NTP is 8.96×10^{-5} g/c.c. Calculate the root-mean-square velocity for an oxygen molecule at NTP.
 - (b) Callendar's formula regarding platinum temperature t_P is given by

$$t - t_P = K \left\{ \left(\frac{t}{100} \right)^2 - \left(\frac{t}{100} \right) \right\}$$

Find an expression for K if

$$R_t = R_0 (1 + \alpha t + \beta t^2)$$

- (c) Establish Stefan's law $E = \sigma T^4$ from Planck's radiation formula.
- (d) Explain entropy of a thermodynamic system.
- **3.** Answer any *three* of the following questions:

5×3=15

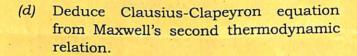
(a) / Derive the relation

$$\left. \frac{\delta s}{\delta V} \right|_{T} = \frac{\delta p}{\delta T} \bigg|_{V}$$

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

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

(c) A cylindrical tube of radii r_1 and r_2 has temperatures θ_1 and θ_2 at the inner and outer surfaces respectively. Show that the temperature will be $\frac{1}{2}(\theta_1 + \theta_2)$ at a distance $\sqrt{r_1 r_2}$ from the axis.



- (e) What is triple point? Discuss the thermodynamics of triple point.
- **4.** (a) Derive Maxwell's law of distribution of velocities of the molecules of a gas. Find the ratio of the average velocity to r.m.s. velocity of the molecules.

Or

Deduce Planck's theory of black-body radiation and show analytically how this formula is used in longer as well as shorter wavelength ranges.



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(b) What are degrees of freedom? State the law of equipartition of energy. Establish that associated energy per degree of freedom is $\frac{1}{2}$ KT.

If the thermal energy of a thermodynamical system is $U = \frac{1}{2} NfKT$, where f is the number of degrees of freedom, find the value of $\gamma = \frac{C_P}{C_V}$ in terms of f. 1+1+6+2=10

Or

- (i) State the second law of thermodynamics in terms of entropy.
- (ii) Obtain an expression for the efficiency of Carnot's engine using a perfect gas as working substance.

2+8=10

(c) Deduce Kirchhoff's law of radiation.

Or

Write short notes on (any two): $5\times 2=10$

- (i) Rayleigh-Jeans law
- (ii) Adiabatic demagnetization
- (iii) Fourier equation for rectilinear flow of heat

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