2013

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) 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

(c) The value of the critical volume V_c according to van der Waals equation is

(i) $V_c = 2b$

(ii) $V_c = b$

(iii) $V_c = 2 \cdot 5b$

(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 γ for an ideal monatomic gas is

(i) $\frac{3}{2}$

(ii) $\frac{5}{2}$

(iii) $\frac{3}{5}$

(iv) $\frac{5}{3}$

(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 : 2×4=8

(a) The density of hydrogen at NTP is $8 \cdot 96 \times 10^{-5}$ 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

$$\left.\frac{\delta s}{\delta V}\right|_T = \left.\frac{\delta p}{\delta T}\right|_V$$

(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.

(d) Deduce Clausius-Clapeyron equation from Maxwell's second thermodynamic relation.

(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. 10

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.

(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. 10

Or

Write short notes on (any *two*) : 5×2=10

(i) Rayleigh-Jeans law

(ii) Adiabatic demagnetization

(iii) Fourier equation for rectilinear flow of heat

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