2018

PHYSICS

(Major)

Paper : 2.2

(Heat and Thermodynamics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following as directed : 1×7=7

(a) Two different gases have the same amount of average kinetic energy. What inference can you draw from this information?

(b) The number of molecules obeying M-B distribution law strike unit area(s) is given by

(i) $\frac{p}{\sqrt{\pi mkt}}$

(ii) $\frac{2p}{\sqrt{\pi mkt}}$

(iii) $\frac{p}{\sqrt{2\pi mkt}}$

(iv) $\frac{4p}{\sqrt{\pi mkt}}$

(Choose the correct one)

(c) What are the possible numbers of degrees of freedom of diatomic gas?

(d) "They come and go, stop mount descend remount again without in the least tending towards immobility."

Which physical phenomenon is described in the above description?

(e) An ideal gas is expanded isothermally such that its volume is doubled, what is the change in internal energy?

(f) Why is Joule-Thomson expansion also called porous plug experiment?

(g) Distribution of energy in the spectrum of a blackbody can be correctly represented by

(i) Wien's law

(ii) Stefan's law

(iii) Planck's law

(iv) Kirchhoff's law

(Choose the correct one)

2. Answer any *four* of the following : 2×4=8

(a) Show that

$$\delta = \frac{C_p}{C_v} = 1 + \frac{2}{f}$$

where f is number of degrees of freedom.

(b) What is meant by quasi-static process? What conditions are to be fulfilled for processes to be quasi-static?

(c) Establish Stefan's law $E = \sigma T^4$ from Planck's radiation formula.

(d) At what temperature will root-mean-square velocity of nitrogen molecule double its value at NTP, pressure remaining constant?

(e) The wavelength of maximum energy in the luner spectrum is found to be $14 \cdot 46 \times 10^{-4}$ cm. If the value of the Wien's constant be 0·293 cm-K, find the luner temperature.

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

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

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

(c) A cylindrical tube of radii r_1 and r_2 have 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) $H = U + PV$ represents enthalpy of a system containing a gas, prove that

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

(e) A Carnot cycle is performed with 1 litre of air ($r = 1 \cdot 4$) initially at 327 °C and a pressure of 12 atm. Each state represents a compression or expansion in the ratio 1·6. Calculate the efficiency of the cycle.

4. Answer any *three* of the following : 10×3=30

(a) What is meant by mean free path? Establish $\bar{\lambda} = \frac{1}{\sqrt{2}\,\pi\sigma^2 n}$ on the basis of kinetic theory of gas. 2+8=10

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

(c) Describe Maxwell's laws of distribution of velocities of the molecules of an ideal gas and find the ratio of average velocity to r.m.s. velocity of the molecules. 10

(d) *(i)* State the second law of thermodynamics in terms of entropy. 2

(ii) Obtain an expression for the efficiency of Carnot's engine using a perfect gas as working substance. 8

(e) What is Joule-Thomson effect? Show that enthalpy remains constant in the Joule-Thomson effect. 10

(f) Write short notes on the following : 5×2=10

(i) Adiabatic demagnetization

(ii) Wien's displacement law

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