3/EH–24 (iii) (Syllabus–2015)

2018

(October)

PHYSICS

(Elective/Honours)

(Thermal Physics, Waves)

[Phy–03 (T)]

Marks : 56

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer Question No. **1** which is compulsory and *any* **four** from the rest

1. *(a)* A 100 gm piece of ice at 0 °C is dropped into a container containing 200 gm of water at 30 °C. Calculate the net change in entropy of the system when the final equilibrium state is reached. Latent heat of fusion of ice = 80 cal. 3

(b) A particle executes SHM with time period 8 s and amplitude 4 cm. Calculate the velocity and acceleration when the particle is 2 cm from central position and also calculate their maximum values. 3

(c) A blackbody at 1500 K emits the maximum energy at wavelength 2000 nm. What is the maximum temperature of the sun, if it emits the maximum energy at wavelength 550 nm? 3

(d) The uncertainty in the velocity of an electron moving with a speed of 500 m/s is 0·004%. Calculate the uncertainty in the position of an electron. 3

2. (a) State and prove the law of equipartition of energy. 1+2=3

(b) Define the critical constants of a gas. Obtain the expressions for the critical constants in terms of the constants a and b of the van der Waals equation. 1½+3½=5

(c) What are the essential features of Brownian motion? Explain why the motions of particles in Brownian motion are random and irregular. 1½+1½=3

3. (a) State and prove Carnot's theorem. 1+3=4

(b) Show that the work done in an adiabatic process depends only on the initial and final temperatures. 3

(Continued)

(c) Explain what you understand by the terms reversible process and irreversible process. 1+1=2

(d) Define Boyle temperature and obtain an expression for it. 2

4. (a) Show that the rate of energy emitted by a blackbody per unit area is proportional to the fourth power of its absolute temperature. 3

(b) Show that Planck radiation law reduces to Rayleigh-Jeans law in the long wavelength limit. 3

(c) What is phase space? Calculate the number of states per unit volume in phase space. 1+2=3

(d) What is a canonical ensemble? For which type of system, it is suitable? 1+1=2

5. (a) Discuss the resultant due to two mutually perpendicular SHMs which are represented by equations $x = 3\sin\omega t$ and $y = 4\cos\omega t$. 4

(b) Graphically represent the displacement, velocity and acceleration of the particle executing SHM. 2

(Turn Over)

(c) What is sharpness of resonance in forced vibration? Discuss the effect of damping on the sharpness of resonance. 1½+1½=3

(d) Write down a differential equation representing damped simple harmonic equation explaining the various terms. 1+1=2

6. (a) What are normal modes of vibration? 1

(b) A perfectly elastic string of length l which is under tension T and fixed at both ends is plucked at a point $x = a$ to a height h and released. Find the different normal modes of vibration. 6

(c) Show that the KE and PE of the plane progressive wave are equal. 4

7. (a) Find the Fourier expansion of a square wave which is given by

$$y(t) = A \quad \text{for} \quad 0 < t < \frac{T}{2}$$

$$y(t) = -A \quad \text{for} \quad \frac{T}{2} < t < T$$ 3

(b) Discuss at least two phenomena that classical physics failed to explain. 3

(c) Illustrate the uncertainty principle by using Heisenberg's microscope. 5

(Continued)

8. (a) An object of mass 100 gm is moving with a velocity of 200 m/sec. Find the de Broglie wavelength of the object. 2

(b) Explain why the wave nature of larger object is hard to detect. 2

(c) Derive the one-dimensional time-dependent and time-independent Schrödinger equations. 4

(d) What is a wave function? Give its physical interpretation. 1+2=3

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