Odd Semester, 2020

(Held in March, 2021)

PHYSICS

(Elective/Honours)

[PHY–03(T)]

(Thermal Physics, Waves)

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 monatomic van der Waals' gas is contained in a cylinder of molar volume $0{\cdot}8$ lit mol^{-1} at a pressure of 36 atm. If $a = 4{\cdot}05$ atm lit^2 mol^{-2}, $b = 0{\cdot}037$ lit mol^{-1} and $R = 0{\cdot}082$ atm lit K^{-1} mol^{-1}, calculate ctirical pressure and temperature of the gas. 3

(b) Two perfectly blackbodies *A* and *B* at temperature 227 °C and 327 °C respectively are kept in evacuated chamber kept at 27 °C. Compare the rate of cooling of *A* and *B*. 3

(c) Calculate the efficiency of a Carnot engine working between 127 °C and 27 °C. It absorbs 80 cal of heat at the source. How much heat is rejected at sink? 3

(d) A body at 1500 K emits maximum energy of wavelength 2000 nm. If the Sun emits maximum energy at 550 nm, what is the temperature of the Sun? 3

2. (a) What is Brownian motion? Give its essential features. 1+3=4

(b) State the law of equipartition of energy. Prove that for a perfect gas whose molecules have f degrees of freedom

$$\frac{C_P}{C_V} = 1 + \frac{2}{f}$$

Hence show that for a mono-atomic gas $\gamma = 1 \cdot 67$ and for a diatomic gas $\gamma = 1 \cdot 4$. 2+4+½+½=7

3. (a) State and explain the first law of thermodynamics. State and prove Carnot's theorem. 2+1+3=6

(b) Explain thermodynamic scale of temperature, and show that the thermodynamic and the ideal gas scales are identical. 1+4=5

4. *(a)* Explain the principle of regenerative cooling. 3

(b) Prove that the pressure of radiation normal to a surface is u, where u is the energy density of radiation. 4

(c) Explain the terms 'Γ-space and Gibbs' ensemble. 2+2=4

5. *(a)* Derive Planck's law of blackbody radiation in terms of wavelength. 6

(b) Calculate the number of states in terms of volume in phase space. 5

6. *(a)* Derive a general differential equation of motion of a simple harmonic oscillator and obtain its solution. 2+3=5

(b) What is damping? On what factors the damping depends? What is the effect of damping on the natural frequency of an oscillator? 1+2+3=6

7. *(a)* Find the Fourier series for $f(x) = x$ in the closed interval $(-\pi, \pi)$. 6

(b) What is interference of sound waves? Is group velocity less than phase velocity or greater than phase velocity? 2+3=5

8. *(a)* What is the wave nature of matter? Obtain an expression of de Broglie wavelength for matter wave. Why cannot we observe de Broglie wavelength with fast moving cricket ball? 1+2+1=4

(b) Apply Heisenberg's uncertainty principle to explain the binding energy of an electron in a hydrogen atom of the order of 15 eV. 4

(c) Discuss the concept of a wave function and give its physical interpretation. 1+2=3

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