

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 0.8 lit mol^{-1} at a pressure of 36 atm. If $a = 4.05 \text{ atm lit}^2 \text{ mol}^{-2}$, $b = 0.037 \text{ lit mol}^{-1}$ and $R = 0.082 \text{ atm lit K}^{-1} \text{ mol}^{-1}$, calculate critical 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 $\gamma = 1.67$ and for a diatomic gas $\gamma = 1.4$. $2+4+\frac{1}{2}+\frac{1}{2}=7$

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

(3)

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? $2+3=5$

(4)

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. $1+2=3$

★ ★ ★