Total No. of Printed Pages : 5 **Roll No. ....**

1(CCE.M)2

Physics–I

(18)

Time : Three Hours] [Maximum Marks : 300

INSTRUCTIONS

(i) Answers must be written in English.

(ii) The number of marks carried by each question is indicated at the end of the question.

(iii) The answer to each question or part thereof should begin on a fresh page.

(iv) Your answer should be precise and coherent.

(v) The part/parts of the same question must be answered together and should not be interposed between answers to other questions.

(vi) Candidates should attempt **six** questions in all. The question no. **1** is compulsory.

(vii) If you encounter any typographical error, please read it as it appears in the text-book.

(viii) Candidates are in their own interest advised to go through the General Instructions on the back side of the title page of the Answer Script for strict adherence.

(ix) No continuation sheets shall be provided to any candidate under any circumstances.

(x) Candidates shall put a cross (×) on blank pages of Answer Script.

(v) Derive the equation $\left(\frac{\partial C_v}{\partial V}\right)_T = T\left(\frac{\partial^2 p}{\partial T^2}\right)_V$ using Maxwell's thermodynamic relation. 20

(vi) Wavelength of two notes in air are $\frac{90}{175}$ m. and $\frac{90}{173}$ m. Each of these notes produces 4 beats/s with a third note of fixed frequency. Calculate this frequency of the third note and velocity of sound in air. 20

(vii) In Young's experiment, interference bands are produced on a screen placed at 75 cm from two slits separated by a distance of 2.5 mm and illuminated by light of wavelength 4800$\mathring{A}$. Obtain the fringe width. What will be the change in the fringe width if the screen is brought towards the slits by 50 cm ? 20

2. If a particle is projected vertically upward to a height h above a point on Earth surface at a northern latitude λ, show that it strikes the ground at a point $\frac{4}{3}\omega\cos\lambda\sqrt{\frac{8h^3}{g}}$ to the west. [Neglect air resistance]. Here ω is the angular velocity of earth's rotation around its own axis; g is acceleration due to gravity. 40

3. Consider a rocket propelled by burning fuel. Let M be the mass of rocket and υ be its speed at time t. In time 'dt' mass of the system decreases by 'dM' due to burning of the fuel. If the fuel is burnt at constant rate and u be the velocity of exhaust gases (with respect to rocket), then :

(i) What is the velocity of the rocket at time t ? (Considering the motion occurs under no gravity)

(ii) What is the maximum velocity attained by the rocket ?

(iii) If the motion occurs under gravity, what is the relation between velocity and time t ? 40

4. (a) Explain Joule-Kelvin effect. What is inversion temperature ? 20

(b) A tungsten filament of length 2 cm and diameter 50 micrometers is heated by passing electrical current through leads. It is enclosed in an evacuated glass bulb. Assuming the emissivity of tungsten to be 0.4, estimate the temperature of the filament if operated at the power of 1 W. ($\sigma = 5.67 \times 10^{-8}$ W/m^2/K^4). 20

5. A mass of 1 kg is placed on top of a block of melting ice. The weight bears upon an area of 1mm^2. By what amount must the temperature of the ice be lowered for it to prevent penetration by the mass ? Assume that no heat flows from the mass (g = 9.81 ms^{-2}, latent heat of fusion of ice = 333 kJ kg^{-1}. Ice floats in cold water with 1/12 of it out of water.) 40

6. (a) The potential energy of an object in simple harmonic motion (SHM) is given by $U = \left(\frac{1}{2}\right)m\omega^2 x^2$, while its kinetic energy $E_k = \frac{1}{2}m\dot{x}^2$. Show that the total mechanical energy is $E_{tot} = \frac{1}{2}m\omega^2 A^2$. 10

(b) A string of length 3 m and total mass 12 g is under a tension of 160 N. A transverse harmonic wave with wavelength 25 cm and amplitude 2 cm travels to the right along the string. It is observed that the displacement at $x = 0$ at $t = 0$ is 0.87 cm. What is the wave function of the wave ? 30

7. (a) With the help of energy level diagram describe as to how population inversion and lasing action is achieved in a He – Ne laser. 30

(b) Explain the spatial and temporal coherence. 10

(xi) No blank page be left in between answer to various questions.

(xii) No programmable Calculator is allowed.

(xiii) No stencil (with different markings) is allowed.

(xiv) The Table of Constants is provided in the question paper.

1. Attempt any **five** of the following :

(i) A cylindrical shell of inner radius r rotates at angular speed ω. A wooden block rests against the inner surface and rotates with it. If the coefficient of static friction between the block and surface is μ_s, how fast must the shell be rotating if the block is not to slip or fall ? [Assume r = 150 cm and μ_s = 0.30] 20

(ii) An alpha-particle of mass m and charge +2e moves in the force field of a heavy nucleus of charge +Ze. The alpha-particle initially at a large distance from the nucleus is travelling with speed $\upsilon(\upsilon << c)$ along a path, which if continued without deviation, would pass at a distance 'b' from the nucleus. What is the distance of closest approach of the actual path of the alpha-particle ? 20

(iii) An artificial satellite revolves around the earth in circular orbit at a height H above the earth's surface. Calculate the period of revolution of the satellite so that the astronaut in it may be in a state of weightlessness. 20

(iv) By what factor does the entropy of the electromagnetic radiation inside an enclosure change when the temperature is increased from 1000K to 2000K ? 20

Physical Constants :

Charge on electron	e = 1.602×10^{-19} coulomb
Mass of an electron	m = 9.109×10^{-31} kg
Velocity of light	$c = 2.998 \times 10^{8}$ m/s
Planck's constant	$h = 6.626 \times 10^{-34}$ Joule-sec.
	$\hbar = 1.055 \times 10^{-34}$ Joule-sec
Boltzmann constant	$k = 1.381 \times 10^{-23}$ J/K
Avogadro's number	$N_A = 6.023 \times 10^{23}$ mol
Bohr Radius	$a_0 = 0.529$ A^0
Bohr magneton	$\mu_B = 9.27 \times 10^{-24}$ J/T
Permittivity of vacuum	$\varepsilon_0 = 8.854 \times 10^{-12}$ F/m
Permeability of vacuum	$\mu_0 = 12.5664 \times 10^{-7}$ Hm^{-1}

1 electron volt = 1.602×10^{-19} J