2018

PHYSICS

(Major)

Paper : 5.3

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Quantum Mechanics)

(*Marks* : 40)

1. Answer any *four* questions as directed : 1×4=4

(a) Select the correct answer :

All the radiation laws can be shown to be special care of

(i) Wien's law

(ii) Rayleigh-Jeans law

(iii) Planck's law

(iv) Stefan-Boltzmann law

(b) Which statement is correct?

(i) Phase velocity (v_p) of light wave is independent of λ in vacuum.

(ii) Phase velocity of matter depends on λ in vacuum.

(iii) Phase velocity of matter wave is independent on λ in vacuum.

(iv) Phase velocity of light wave is dependent on λ in vacuum.

(c) What is the ground-state energy of a linear harmonic oscillator?

(d) Show that

$$\left[x, \frac{\delta^2}{\delta x^2}\right] = -2\frac{\delta}{\delta x}$$

(e) What is the total number of energy level (or degeneracy) for *n*th state of hydrogen atom?

2. Answer any *three* questions : 2×3=6

(a) A radio station operates at frequency of 103·7 Hz with a power output of 200 kW. Determine the rate of emission of quanta from the station.

(b) What is the physical significance of the wave function $\psi(x, t)$?

(c) Assume the uncertainty in the location of a particle is equal to its de Broglie wavelength. Show that the uncertainty in the velocity is equal to its velocity.

(d) What is quantum mechanical tunnelling? Under what condition, the transmission coefficient $T = 1$?

(e) Draw the wave function of a particle in a box of infinite depth.

3. Answer any *four* questions : 5×4=20

(a) The energy distribution of blackbody radiation is given by Planck's law :

$$\rho(\lambda T) = 8\pi hc / \lambda^5 \frac{1}{\exp\left(\frac{hc}{\lambda kT}\right) - 1}$$

Show that for long wavelength

$$\rho(\lambda, T) \to 8\pi kT / \lambda^4$$

and for short wavelength

$$\rho(\lambda T) \to 8\pi hc / \lambda^5 \exp\left(\frac{-hc}{\lambda kT}\right)$$

What is Planck's quantum hypothesis? Mention one experiment for determining Planck's constant h. 3+1+1=5

(b) An α-particle is accelerated through a potential difference of 2000 volts. What is the wavelength of the associated de Broglie wave?

Given, mass of the proton = $1 \cdot 67 \times 10^{-27}$ gms

Planck's constant $h = 6 \cdot 62 \times 10^{-27}$ erg sec 5

(c) (i) State and explain Heisenberg uncertainty principle.

(ii) Give an account of the γ ray microscope experiment. 2+3=5

(d) Explain the need for differential wave equation. Starting from the wave equation and introducing energy and momentum of the particle, obtain three-dimensional Schrödinger equation in time-dependent form. 2+3=5

(e) (i) What is one-dimensional potential step? 1

(ii) A particle of mass m is moving in one-dimensional potential given by

$$V = \begin{cases} 0 & \text{for } x < 0 \\ v_0 & \text{for } x > 0 \end{cases}$$

If energy E of the incident particle is greater than v_0, then calculate the coefficients of refraction and transmission. 2+2=4

(Continued)

4. Answer any *two* questions : 5×2=10

(a) *(i)* What is an observable corresponding to a quantum mechanical system?

(ii) Establish the relation

$$[L_x, L_y] = i\hbar L_z;\ [L^2 L_z] = 0$$

where the notations have their usual meanings. What conclusion about the eigenfunction of the operators involved can be shown from those relation? 1+4=5

(b) Discuss the wave mechanics of the electron in a hydrogen atom in a spherically symmetric potential and derive the energy state and energy function. 2+3=5

(c) Briefly discuss G. P. Thomson's experiment of electron diffraction, and its significance for quantum theory. 5

GROUP—B

(Astrophysics)

(*Marks* : 20)

5. Answer any *three* from the following : 2×3=6

(a) Draw a neat diagram of the celestial sphere showing a star in northern hemisphere, the celestial equator hour angle and the right ascension of the star. 2

(b) If one P-P chain transform $4{\cdot}8\times10^{-29}$ kg, then how many reaction cycles must produce the total transformed mass per second? 2

(c) What is universal time? Express 2165 sidereal days in terms of mean solar days. 2

(d) What do you mean by color index? What is the declination (δ) at celestial pole and celestial equator? 1+1=2

(e) Calculate the temperature of Sun from the following data : 2

$$\lambda_m T = 0\cdot287,\ \lambda_m = 4753\ \text{Å}$$

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

(a) How are the spectra classified? What are the various spectral classes? Show that the colour of a star defines a spectral class. 1+1+2=4

(b) What is the main process that creates energy in solar system? Discuss P-P cycle. What is the end product of CNO cycle reaction under equilibrium condition? 1+2+1=4

(c) A star has a proper motion of 10 arc second per year. It is about 2 per sec away. The star radial velocity is measured to be 100 km/sec, i.e. it is moving towards the earth. Calculate star's space velocity. 4

7. Write short notes on any *two* of the following : 3×2=6

(a) Sidereal time

(b) Pulsars

(c) H-R diagram

(d) Black hole

★★★