SEM-IV UG1 Physics Honours

ASSIGNMENTS : April 2020

T. Mukherjee, e-mail: tapas.mukherjee1@gmail.com

SUB:Modern Physics (Emergence of Quantum Theory)

Full Marks: 60

1. Using the concept of discrete energy and Boltzmann probability distribution; find the average energy per mode of oscillation of an assembly of harmonic oscillators. Hence deduce the spectral distribution function assuming the number of modes per unit volume to be $\left(8\pi/\lambda^4\right)$. 5
2. Find the average energy density of the oscillators in the classical limit. Hence show that Planck's law of radiation reduces to Rayleigh-Jeans law. 3
3. Show that Planck's law of radiation reduces to Wien's law in the short wavelength limit. 3
4. Show that the relativistic de Broglie wavelength is given by

$$\lambda_r = \frac{hc}{\sqrt{E_k\left(E_k + 2m_0c^2\right)}}$$

3

5. A particle of charge e and rest mass m_0 is accelerated by an electrical potential V. What is the de Broglie wavelength of the particle viewing the relativistic energy momentum relation. What would be the de Broglie wavelength if the relativistic effect is not taken into account.. Given $e = 1.6\times10^{-19}C$ and $m_0 = 9.1\times10^{-31}kg$ 4
6. Monochromatic radiation at wavelength of 300 nm is incident on a piece of barium (photoelectric waork function 2.5 eV). Will there be any photoelectric emission? If yes, find the maximum kinetic energy of the photoelectron. Also find maximum velocity of the photoelectrons. What is the stopping potential in this case? 5
7. X-rays with wavelength 1 Angstrom are scattered from a carbon block. The scattered radiation is viewed at 90 degree to the incident beam. Calculate the Compton shift and the kinetic energy imparted to the recoiled electron. 4

8. Consider the nth orbit of a hydrogen like atom to fit to n number of stationary de Broglie wave. Show that it leads to Bohr's postulate of quantization of angular momentum. 3
9. Show that the de Broglie wavelength of a particle is approximately the same as that of photon of same energy, when the energy of the particle is much greater than the rest mass energy. 3
10. Find the relation between the phase velocity and group velocity of the de Broglie waves. 3
11. Show that the group velocity of the de Broglie wave is equal to the velocity of the particle. 3
12. In Davission-Germer experiment, the diffraction maxima occurs at an angle 50 degree where the electron accelerating potential is 54 eV at the atomic spacing for single nickel crystal is 2.15 Angstrom. From this data show that the experiment is in agreement with de Broglie hypothesis. 3
13. An electron and a proton have the same kinetic energy. Compare the phase and group velocities of their de Broglie waves. 3
14. Assuming that there are integral number of de Broglie waves in a region which corresponds to uncertainty in the measurement of position, establish Heisenberg's uncertainy relation. 3
15. Use Heisenberg's uncertainty principle to prove that electron can't reside inside the nucleus. 3
16. Consider a particle confined in a one dimensional box of length l . Using Heisenberg's uncertainty principle estimate minimum energy of the particle. 3
17. Usr Heisenberg's uncertainty principle to estimate the Bhor's radius and hence the ground state energy of the hydrogen atom. 3
18. An atomic state has a lifetime of $10 \mu s$. Find the natural line-width of the corresponding electromagnetic radiation. 3