Roll No……..….. **Total No. of Printed Pages: [02]**
Total No. of Questions: [09]

B.Sc. Hons. Physics (Semester – 3rd)
ELEMENTS OF MODERN PHYSICS
Subject Code: BPHYS1302
Paper ID: [19131516]

Time: 03 Hours **Maximum Marks: 60**

Instruction for candidates:

1. Section A is compulsory. It consists of 10 parts of two marks each.
2. Section B consist of 5 questions of 5 marks each. The student has to attempt any 4 questions out of it.
3. Section C consist of 3 questions of 10 marks each. The student has to attempt any 2 questions.

Section – A **(2 marks each)**

Q1. Attempt the following:

a. What assumptions were made by Planck in dealing with the problem of blackbody radiations? Also discuss the consequences of these assumptions.

b. A sodium-vapor lamp has a power output of $10\,W$. Using $589.3\,nm$ as the average wavelength of the source, calculate the number of photons emitted per second.

c. Estimate the kinetic energy of an electron confined within a nucleus of size $1.0\times10^{-14}\,m$ by using the uncertainty principle.

d. If matter has a wave nature, why is this wavelike character not observable in our daily experiences?

e. K with mass number 40 is an unusual isotope, in that it decays by negative beta emission, positive beta emission, and electron capture. Write down these reactions.

f. Find the total binding energy B and also the average binding energy per nucleon(B/A) for Fe_{26}^{56}.

g. The alpha particle is a particularly tightly bound nucleus. Based on this fact, explain why heavy nuclei undergo alpha decay and light nuclei do not.

h. For laser action to occur, the medium used must have at least three energy levels. What must be the nature of each of these levels? Why is three the minimum number?

i. Define the terms spatial and temporal coherence in context to the Lasers.

j. Certain ocean waves travel with a phase velocity $v_{phase} = \frac{g\lambda}{2\pi}$, where g is the acceleration due to gravity. What is the group velocity of a **"wave packet**" of these waves?

Section – B **(5 marks each)**

Q2. A beam of electrons with kinetic energy $350\ eV$ is incident normal to the surface of a KCl crystal that has been cut so that the spacing D between adjacent atoms in the planes parallel to the surface is $0.315\ nm$. Calculate the angle at which diffraction peaks will occur for all orders possible.

Q3. (i) Yellow light is passing through two slits and an interference pattern is observed on a screen. What will be the impact on the fringes of the interference pattern if

a. Yellow light is replaced with blue light.

b. The distance between two slits is reduced.

Give the relevant proofs to support your answer.

(ii) A light falls on two slits $2mm$ apart and produces on a screen $1m$ away from the fourth-order bright line $1mm$ from the center of the pattern. What is the wavelength of the light used?

Q4. What do you understand by population inversion? Calculate the population ratio of two states in He-Ne laser that produces light of wavelength $6000\ Angstrom$ at $300\ K$.

Q5. Draw a neat diagram of Semiconductor Laser, discuss its working and applications.

Q6. What is Heisenberg's gamma ray microscope? Giving the details of the gamma ray microscope though experiment, discuss the importance of the same.

Section – C **(10 marks each)**

Q7. A photon of certain initial energy undergoes Compton scattering at certain angle. Derive an expression for the shift in the wavelength of the scattered photon.

Q8. **a.** Briefly describe the various terms involved in Semi-Empirical Mass Formula (liquid drop model) along-with their origin. **6**

b. A neutron, which has no electric charge, has a magnetic dipole moment. How is this possible? **2**

c. Why is the binding energy per nucleon relatively constant? Why does it deviate from a constant value for low mass numbers? **2**

Q9. **a.** Derive the expression for the Einstein Coefficients and show that in thermal equilibrium, for an optical source with temperature,$T = 103K$, and angular frequency, $\omega = 3\times10^{15}\ sec^{-1}$, the emission processes are dominated by spontaneous emission. **6.**

b. Write a short note on Q-switching and mode locking in Lasers? **4**