U.G. 5th Semester Examination - 2024

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-P-11

(Quantum Mechanics & Applications)

[New Syllabus]

[PRACTICAL]

Full Marks : 20 Time : 2 Hours

The figures in the right-hand margin indicate marks.

Distribution of Marks:

Experiment - 10

Viva-Voce - 05

Lab. Note Book - 05

Answer any **one** of the following:: 10×1=10

Use C/C++/Scilab/Python/Fortran for solving Q. no 1 to 5.

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$\frac{d^2y}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ and $V(r) = -\frac{e^2}{r}$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ - 13.6eV. Take e=3.795 $(eV\,Å)^{1/2}$, $\hbar c$=1973(eV Å) and m=0.511×10^6 eV/c^2.

[Turn over]

2. Solve the s-wave radial Schrodinger equation for an atom:

$\frac{d^2y}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ and $V(r)$ is the screened Coulomb potential having the form $V(r) = -\frac{e^2}{r}e^{-\frac{r}{a}}$.

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits.

Also, plot the corresponding wavefunction. Take e=3.795(eV Å)$^{1/2}$, m=0.511×10^6 eV/c^2 and a=3 Å, 5 Å, 7 Å. In these units $\hbar c$ = 1973 (eV Å).

3. Solve the s-wave radial Schrodinger equation for an atom:

$\frac{d^2y}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ and $V(r) = \frac{1}{2}kr^2$ is the harmonic oscillator potential.

Solve the equation for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k=100 MeV fm^{-2}. In these units, $c\hbar$ = 197.3 MeV fm.

4. Solve the s-wave radial Schrodinger equation for an atom:

$\frac{d^2y}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ and $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$ is the anharmonic oscillator potential.

Solve the equation for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k=l00 MeV fm^{-2}, b=0, l0, 30 MeVfm^{-3}. In these units, $c\hbar$=197.3 MeV fm.

5. Solve the s-wave radial Schrodinger equation for the vibration of hydrogen molecule:

$\frac{d^2y}{dr^2} = A(r)u(r)$, $A(r) = \frac{2\mu}{\hbar^2}[V(r) - E]$ where μ is the reduced mass of the two-atom system for the Morse potential.

$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), r' = \frac{r - r_0}{r_0}$, is the anharmonic oscillator potential.

Solve the equation for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = l00 MeV fm^{-2}, b = 0, l0, 30 MeV fm^{-3}. In these units, $c\hbar$=l97.3 MeV fm. Find the lowest vibrational energy (in MeV) of the

molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: $m = 940\times10^6 eV/C^2$, $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

6. Study the Electron spin resonance and determine magnetic field as a function of the resonance frequency.

7. Study Zeeman effect of Hg or Na line with external magnetic field and calculate the Hyperfine splitting.

8. Show the tunneling effect in tunnel diode using I-V characteristics.

9. Find out Quantum efficiency of CCD s.
