

1. A metal surface illuminated by 8.5×10^{14} Hz light emits electrons whose maximum energy is 0.52 eV. The same surface illuminated by 12.0×10^{14} Hz light emits electrons whose maximum energy is 1.97 eV. From these data find Planck's constant and the work function of the surface. (16%)

2. An unstable elementary particle called the eta meson has a rest mass of 549 MeV/c² and a mean lifetime of 7.00×10^{-19} s. Consider a nonrelativistic calculation for $E = mc^2$, what is the uncertainty in its rest mass? (16%)

3. (a) When radiation with a continuous spectrum is passed through a volume of hydrogen gas whose atoms are all in the ground state, which spectral series will be present in the resulting absorption spectrum? (12%)

(b) The longest wavelength in the Lyman series is 121.5 nm and the shortest wavelength in the Balmer series is 364.6 nm. Find the longest wavelength of light that could ionize hydrogen. (12%)

Hint: Lyman series: E(n) to E(n=1), Balmer series: E(n) to E(n=2), Paschen series: E(n) to E(n=3), Brackett series: E(n) to E(n=4).

4. A particle is in a 3D cubic box with infinitely hard walls whose edges are L long. The wave functions of the particle are given by $\psi = A \sin(n_x \pi x / L) \sin(n_y \pi y / L) \sin(n_z \pi z / L)$ where $n_x = 1, 2, 3, \dots$, $n_y = 1, 2, 3, \dots$, and $n_z = 1, 2, 3, \dots$

(a) Find the value of the normalization of constant A . (8%)

(b) If the particle is in its ground state of $n_x = n_y = n_z = 1$, find the probability that the particle will be found in the volume defined by $0 \leq x \leq L/2$, $0 \leq y \leq L/2$, $0 \leq z \leq L/2$. (8%)

(c) Find the possible energies of the particle in the box by substituting its wave function in Schrodinger's equation and solving for E . (Hint: Inside the box $U = 0$). (8%)

(d) Guess the expectation value of momentum $\langle p \rangle$ of its ground state. How about $\langle p^{+x} \rangle$? Here, $+x$ means the particle moves in $+x$ direction. (8%)

5. Find the number of ways in which two particles can be distributed in six states in below cases.

(a) The particles are distinguishable. (4%)

(b) The particles are indistinguishable and obey Bose-Einstein statistics. (4%)

(c) The particles are indistinguishable and only one particle can occupy any one state. (4%)