參考用

(1) A γ ray with wavelength $5\times10^{-12}m$ is incident on an electron m_e initially at rest. The electron is observed to recoil with kinetic energy $60keV$.

(a) Calculate the energy of the scattered γ ray (in keV). (10%)

(b) Determine the direction in which it is scattered. (10%)

[the rest mass of electron is $m_ec^2 = 0.51MeV$,
Planck constant is $h = 4.1357\times10^{-15}eV\cdot s$]

(2) A $1000kg$ satellite is in a circular orbit about the earth with a period of 2 hours.

(a) Applying the Bohr quantum condition on angular momentum, calculate the quantum number n for this orbit. (10%)

(b) Find the radius of this orbit. (5%)

(c) Find the radial distance between this orbit and the next allowed higher orbit. Could we experimently detect this distance ? (5%)

[the radius of the earth is $R_e = 6.37\times10^6 m$,
the gravitational acceleration on the earth surface is $g = 9.8m/s^2$,
Planck constant is $h = 6.626\times10^{-34} J\cdot s$]

(3)

(a) Obtain values (in eV) for the energies in the energy level diagram for singly ionized helium H_e^+. (5%)

(b) Identify all transitions in H_e^+ for which the emitted wavelengths are in the visible range $3500-7000\,\mathring{A}$. (15%)

[the permitivity of vacuum is $\varepsilon_0 = 8.8\times10^{-12}F/m$,
the electron mass is $m_e = 9.1\times10^{-31}kg$,
the electron charge is $e = 1.6\times10^{-19}C$]

(4) Consider an oscillating mass m on a spring with spring-constant κ. The energy is given by

$$E = \frac{<p^2>}{2m} + \frac{\kappa <x^2>}{2}$$

where $<p^2>$ and $<x^2>$ are the average values of p^2 and x^2, respectively.

(a) Determine the uncertainty of position Δx at which the energy is minimum. (10%)

(b) Determine the minimum energy, in terms of the angular frequency of a classical oscillator $\omega = \sqrt{\kappa / m}$. (5%)

(5) A particle has mass m in a one-dimensional box is confined to the interval $(-\frac{a}{2}, \frac{a}{2})$ and is in its first excited state. Calculate the probability of finding the particle in the subinterval $(-\frac{a}{8}, \frac{a}{8})$. (10%)

(6)

(a) Sketch the normal Zeeman splitting for the transition of the $4p$ and $3d$ energy levels of the hydrogen atom. (5%)

(b) Calculate the magnitude of the splitting in a 2 Tesla applied magnetic field. (10%)

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