

八十五學年度 原子科學系(所) 甲 組碩士班研究生入學考試
 科目 近代物理 科號 4003 共 三 頁第 一 頁 *請在試卷【答案卷】內作答

Note: 10 points for each problem

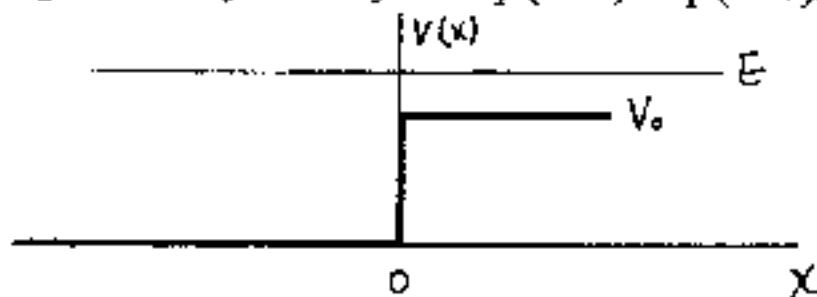
- A particle is bound by the infinite square well potential to the region $-a/2 \leq x \leq +a/2$.

 - Is the lowest possible total energy of the particle zero?
 - Please state your reason if your answer of (a) is no.
- Two light sources are at rest in inertial system S at position x_1 and x_2 . At time $t=t_0$ they each emit a light in the Y direction. The lights are received by two receivers at rest in inertial system S' , which moves with a velocity V with respect to S . How far apart is these two receivers?
- Apply Bohr's model to singly ionized helium and find the wavelength of the transition from a state with $n = 4$ to a state with $n = 2$.

$R_\infty = 109737 \text{ cm}^{-1}$

proton rest mass $m_p = 1.672 \times 10^{-27} \text{ kg}$; neutron rest mass $m_n = 1.675 \times 10^{-27} \text{ kg}$;
 electron rest mass $m_e = 9.109 \times 10^{-31} \text{ kg}$.
- A particle under the influence of a step potential as shown below. The total energy E is greater than the height V_0 of the step.

 - Please find the eigenfunctions that can describe the motion of the particle.
 - Draw the probability density with $p(x < 0) = 2p(x > 0)$, where p is momentum.



- Show the allowed transitions between $2p3d\ ^1F_3$ and $2p^2\ ^1D_2$ when an external field of 0.1 tesla is applied. Sketch the spectrum of these transitions and compare to the spectrum when there is no external field.

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科目 近代物理 科號 4003 共 二 頁第 二 頁 *請在試卷【答案卷】內作答

6. Consider the ground state of Al atom with $Z=13$. Please answer the following questions.
- Give the electron configuration.
 - Give the magnitudes of \vec{L} , \vec{S} and \vec{J} in terms of \hbar .
 - Find the angle between \vec{L} and \vec{S} .
 - Express the orbital and spin magnetic dipole moments in terms of μ_B , \hbar , \vec{L} and \vec{S} .
 - Find the angle between \vec{J} and the $+z$ axis.
7. Please express β^+ decay in a way similar to $A+B \rightarrow C+D$ and give the energetic condition for such decay to occur.
8. Predict the LS coupling quantum numbers for the ground state of ${}_{14}\text{Si}$ atom.
9. Consider a photon interacts with a lead nucleus.
- What is the threshold energy needed by the photon for pair production process to occur?
 - Do you neglect the energy of the recoil nucleus in answer given in (a)? Please verify. The mass of Pb nucleus is about 208 u. $1 \text{ u} = 1.661 \times 10^{-27} \text{ kg}$.
10. Compare the spectra of two blackbodies, A and B, of temperature 1000K and 3000K, respectively. There are two formulas below, one is based on classical and the other is on quantum theory. Choose the right formula and answer the questions below. You may need to modify the formula. Please show how you obtain the answer.

$$\rho_T(\nu)d\nu = \frac{8\pi\nu^2 kT}{c^3} d\nu \quad \rho_T(\lambda)d\lambda = \frac{8\pi hc}{\lambda^5} \frac{d\lambda}{e^{hc/\lambda kT} - 1}$$

- The ratio of R_T .
- The ratio of ν_{\max} .
- The ratio of $\rho_T(\nu_{\max})$.