# 國　立　清　華　大　學　命　題　紙

九十三學年度 物理 系（所） ＿＿＿＿ 組碩士班入學考試

科目 近代物理 科號 0401 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

每題二十分

1　簡答題：

a) 電子在作能階躍遷時的 selection rules，請問是如何決定的？以簡諧位能 $\frac{K}{2}x^2$ 爲例，微擾 $\alpha x$（$\alpha$ 是常數）所對應的 selection rule 是什麼？

b) 爲什麼量物課本在前幾章總會提黑體輻射，到底它有什麼重要性？

c) 量子穿隧(quantum tunneling)是量子力學裡一個很吸引人的現象，妳有沒有想過這是否表示密閉藥罐裡的藥，只要搖的夠用力、夠久，的確應該有可能掉出來？同樣道理，如果要妳去撞教室的牆，是不是只要橫下心，死命的撞，總有一天會出現在牆的另外一邊？請給出理由佐證你的看法。

d) 三維空間裡的量子粒子，由於不可區分性(indistinguishability)，可以分成滿足 Pauli exclusion principle 的 fermions 和不滿足的 bosons 兩種。請說明如何從不可區分性導出這個結論？並解釋爲什麼只有這兩種可能？

e) 爲什麼在量子力學裡，要把物理量改寫成算符形式(operators，例如動量 $\hat{p}_x = \frac{1}{i}\frac{\partial}{\partial x}$)？它和測不準原理有什麼關連？

2　名詞解釋：

a) singlet and triplet states for two spins;　b) Zeeman energy

c) Fermi Golden rule;　d) Fermi energy;

e) Spherical harmonics, $Y_{\ell,m}(\theta,\phi)$.

3　A one-dimensional particle of mass $m$ is confined to a region of length $2a$, i.e., $V(x)=\begin{cases}0, & -a<x<a\\ \infty, & \text{elsewhere}\end{cases}$. The wavefunction of this particle at $t$=0 is $\psi(x)=\begin{cases}C(a^2-x^2), & -a<x<a\\ 0, & \text{elsewhere}\end{cases}$ where $C$ is a constant to be determined.

a) What are the possible measured energies of this particle?

b) What is the averaged measured energy?

c) Evaluate the uncertainty $\Delta x \cdot \Delta p$ of this particle.

4 Consider the scattering of a right-going particle of mass $m$ by the potential $V(x)=A\delta(x)+V_0\theta(x)$ where $A$ and $V_0$ are constants, $\delta(x)$ is a delta-function and $\theta(x)$ a step-function. The energy of the particle is $E>V_0$.

a) Find the probability that this particle is transmitted to the $x>0$ region.

b) Evaluate the flux, or probability current, in both $x>0$ and $x<0$ regions.

5 An electron of magnetic moment $\vec{M}$ in a magnetic field $\vec{B}=B_z\hat{z}$ is described by the Hamiltonian: $H=-\vec{M}\cdot\vec{B}=\hbar\omega\sigma_z$ where $\omega=-\frac{egB_z}{4mc}$. The electron at $t=0$ is in an eigenstate of $\sigma_x$ with the eigenvalue of 1, i.e., $\sigma_x\psi(0)=\psi(0)$. Note that $\sigma_x=\begin{pmatrix}0&1\\1&0\end{pmatrix}$ and $\sigma_z=\begin{pmatrix}1&0\\0&-1\end{pmatrix}$ are Pauli matrices.

a) Find the initial state $\psi(0)$.

b) Evaluate the expectation values $\langle H\rangle$ and $\langle\sigma_x\rangle$ at $t>0$.