國立成功大學

113學年度碩士班招生考試試題

編　號：40

系　所：光電科學與工程學系

科　目：近代物理

日　期：0202

節　次：第 1 節

備　註：不可使用計算機

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※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Explain the specific differences in the physical characteristics of mechanical waves, electromagnetic waves, and matter waves **(5 pts)**. Additionally, discuss what information can be derived from the square of the magnitude of a particle's wave function **(5 pts)**.
2. Please write down the complete Schrödinger Wave Equation for the wave function $\phi(x,t)$ describing a particle in a potential $V(x,t)$ in one dimension. Additionally, elucidate under what circumstances we can represent the Schrödinger equation in a form that is independent of time. **(5 pts)**
3. Solve the Schrödinger Wave Equation for a particle with mass m confined to a 3D infinite potential box with sides of length $Lx = Ly = Lz = a$. **(5 pts)**
4. In addition to solving the equation in **3.**, calculate the expectation value of the particle's position and momentum within the 3D box for the first excited state, considering the particle's mass m. Justify your calculations and offer a detailed interpretation of the physical significance of these expectation values in the context of quantum mechanics. **(5 pts)**
5. For a proton with position uncertainty $\Delta x = 2 \times 10^{-11} m$ at a certain moment, what is the uncertainty of the position of the proton one second later? **(5 pts)**
6. Write down the selection rule of hydrogen atom (under the consideration of LS and JJ coupling) **(5 pts)**. How many lines would you occur for a n=4 → n=3 transition? Please draw all the lines. **(5 pts)**
7. Explain the concepts of Singlet State quantum and Triplet State. In the context of electron spin systems, what specific spin arrangements do these states represent? Describe the significance of their quantum numbers, including the spin states and corresponding mathematical expressions. Compare the characteristics of Singlet State and Triplet State and discuss the applications and importance of these spin states in real-world physical systems within quantum mechanics. **(5 pts)**
8. Estimate the band width of a crystal at quantum number n=2 based on the Brillouin zone obtained from the Kronig-Penney model. Assume the lattice constant in the crystal is a=2Å. **(5 pts)**
9. A particle is enclosed in a rectangular box with impenetrable walls, inside which it can move freely, i.e.

$$V(x) = V(y) = V(z) = \begin{cases} 0, if\ 0 < x < a, \quad 0 < y < b, \quad 0 < z < c, \\ \infty \quad outside\ thease\ intervals. \end{cases}$$

   Find (a) the eigenfunctions, **(10 pts)** and (b) the possible values of the energy. **(5 pts)** (c) What can be said about the degeneracy, if any, of the eigenfunctions. **(5 pts)**
10. Show that the eigenkets of any Hermitian operator are orthogonal to each other if the eigenvalues are different. **(10 pts)**
11. Calculate the electric field needed to make the rise time of the oil drop equal to its field-free fall time. **(10 pts)**
12. Determine the minimum angle that $\vec{L}$ can make with the z axis when the angular momentum quantum number is (a) $\ell = 5$ **(5 pts)** and (b) $\ell = 3$. **(5 pts)**