注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：聯合招生

科目代碼：9802

考試科目：近代物理

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「▛ 由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：聯合招生 (0598)

考試科目（代碼）：近代物理 (9802)

$h = 6.63 \times 10^{-34}$ J·s = 4.14×10^{-15} eV·s, $c = 3 \times 10^{8}$ m/s, hc = 1240 eV·nm,
$m_e = 9.11 \times 10^{-31}$ kg, $R = 1.097 \times 10^{7}$ m^{-1}, the rest energy of an electron = 511 keV
$\mu_B = 9.27 \times 10^{-24}$ J/T, 1 eV = 1.602×10^{-19} J, 1 pm = 10^{-12} m

Part A. Please answer the questions "in brief". (Explanation is NOT necessary.)

1. (6%) Please specify the (1) Symbols, (2) Values of Ranges and their Correlations of the (A) Principal, (B) Orbital angular and (C) Magnetic quantum numbers.

2. (4%) Please write down the Electronic Configurations of (1) a Co atom (atomic number = 27) and (2) Co^{2+}, in terms of *s*, *p*, *d*.

3. (3%) Please write down THREE Phenomena concerning photons transferring energies to matters/particles.

4. (3%) Which experiment(s) or phenomenon(a) is/are related to the concept of "Quantum"? (A) Blackbody radiation, (B) Photoelectric effect, (C) Compton scattering, (D) Bremsstrahlung and (E) Zeeman effect.

5. (3%) Which equipment(s) is/are related to the theories or concepts of "Quantum"? (A) Scanning tunneling microscope, (B) Transmission electron microscope, (C) Atomic absorption spectrometry and (D) Rutherford backscattering spectrometry.

Part B. Please answer the questions "in detail".

6. (6%) (1) What the is the Heisenberg Uncertainty Principle? (Please write down TWO types of equations and explain their meanings.)
   (1%) (2) Is the uncertainty due to the inaccuracy of measurement? (Yes or No) _

7. (5%) Please write down the Equation of one-dimensional time-independent Schrodinger equation (THREE terms) and explain each component of this equation.

8. (5%) Please draws the Allowed Projections of the orbital angular momentum of a state with $l = 2$. (Please specify their z components and the length of the vector $\vec{L}$.)

Part B. Please answer the questions "in detail".

9. (6%) (1) Please define Zero-Point Energy (ZPE). (2) Please explain zero-point energy in terms of both (A) Harmonic oscillator and (B) A trapped particle in a one-dimensional box.

10. (14%) Please draw the (1) Potential well and Energy levels with specifying their ZPEs) and (2) Correlation between E_n and their quantum number of (A) Harmonic oscillator for n = 0 ~ 3 and (B) Infinite square well potential for n =1 ~ 3.
(3) Please specify if their energy level intervals are equal?

11. (10%) How did Davisson and Germer prove the electron's wave property? (Please answer this question by simply drawing and explaining the experimental results, and prove the electron's wave property by using some relations/equations for its de Broglie wavelength from known or/and measured parameters.)

Part C. Calculations (Detailed calculation steps should be shown.)

12. (10%) An electron has a de Broglie wavelength of 1 pm. Please calculate its (1) Kinetic energy, (2) Phase velocity, and (3) Group velocities of its de Broglie waves. (Relativistic effects should be considered.)

13. (4%) For a free particle, $\Psi = A\, e^{i(kx-\omega t)}$, please calculate the Expectation Value of Momentum.

14. (10%) The electron in a H atom at rest makes a transition from the 1st excited state to ground state. Please calculate the (1) Wavelength (nm), (2) Frequency (Hz) and (3) Energy (eV) of the electromagnetic wave emitted.

15. (10%) Please calculate the Change in Wavelength (nm) of the 2p → 1s photon when a H atom is under a magnetic field of 1 T.