國立臺北科技大學 111 學年度碩士班招生考試

系所組別：2403 光電工程系碩士班

第二節　近代物理　試題（選考）

注意事項：

1. 本試題共 11 題，共 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

Useful constants:

Electron mass $m_e = 9.11\times10^{-31}$ (kg)

Planck's constant $h = 6.63\times10^{-34}$ (J·s)

Rydberg's constant $R_H = 1.097\times10^{7}$ $(m)^{-1}$

1 eV = 1.6×10^{-19} (J)

Part 1: Short Question

(Please answer the following questions **briefly**)

[1] Max Planck proposed a postulate as developing a theory to successfully explain the spectral distribution of black-body radiation. Please explain it. (4%)

[2] Please explain Bohr's postulates as developing an atomic theory for the hydrogen atom. (6%)

[3] Please explain the meanings of wave-particle duality of light (3%) and matter (3%).

[4] Please apply the concept of quantum numbers to explain Pauli Exclusion Principle. (4%)

[5] Please explain the physical meaning (3%) of a one-dimensional wave function $\psi(x)$ and write down its unit (SI) (2%).

Part 2: Calculation Problem

(Please answer the following problems with **detailed** procedures)

[6] In a photo-electric effect experiment, the kinetic energies of photo-electrons range from zero to 4.3×10^{-19} J when light with 310 nm wavelength falls on a metal surface. Please find:

(a) The stopping potential for this light; (5%)

(b) The threshold wavelength for this metal. (5%)

[7] In a Compton-effect experiment, a 160-pm X-ray photon scatters off an electron and emerges at 125° to its original direction. Please find:

(a) The wavelength of the scattered X-ray photon; (8%)

(b) The kinetic energy of the electron in eV. (7%)

[8] If a Rydberg hydrogen drops from the n=180 level to n=177 level, please find:

(a) The wavelength (5%) and

(b) The energy in eV of the photo emitted (5%).

[9] If an experimental transistor uses a single electron trapped in a 6.8-nm wide quantum-well channel, please apply Heisenberg uncertainty principle to calculate the minimum kinetic energy in eV that this electron could have. (10%)

[10] A particle's wave function is given by $\psi(x) = Ae^{-x^2/a^2}$, where A and a are real constants. Please find:

(a) The probability that the particle is most likely to be found (P_{max}); (7%)

(b) The location where the probability density is $\frac{1}{2}(P_{max})$. (8%)

[11]

(a) An electron in a long, organic molecule used in a dye laser behaves like a particle in a box with width 4.16 nm. Please find the wavelength of the photon emitted when the electron undergoes a transition from the second excited level to the first excited level. (3%)

(b) The wave function of a particle in a box can be expressed as $\psi(x) = \sqrt{\frac{2}{L}}\sin(\frac{n\pi x}{L})$ by solving time-independent Schrodinger equation in a deep square potential well with width L. Please calculate the probability of finding a particle in the region between x=L/4 and x=3L/4 when the particle is in the first excited level. (Hint: Integral by parts). (12%)