# 國立臺北科技大學 112 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 7 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。

electron mass $m_e = 9.11 \times 10^{-31}$ kg　　electron charge $e = -1.6 \times 10^{-19}$ C
Planck constant $h = 6.63 \times 10^{-34}$ Js　　light speed $c = 3.0 \times 10^{8}$ m/s
permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/Nm^2$

1. A continuous-wave He-Ne laser produces a 5 mW light beam at a wavelength of 632.8 nm.
(1) How many photons per second are emitted? (5%)
(2) What is the momentum of each photon in the light beam? (5%)

2. The stopping potential for electrons emitted from a surface illuminated by light of wavelength 491 nm is 0.710 V. When the incident wavelength is changed to a new value, the stopping potential is 1.43 V.
(1) What is this new wavelength? (5%)
(2) What is the work function for the surface? (5%)

3. Electrons are moving with a velocity of $4.0 \times 10^6$ m/s.
(1) What is the de Broglie wavelength of these electrons? (5%)
(2) If these electrons are used to produce X-rays, what is the shortest wavelength they could produce? (Ignore work function effects.) (5%)

4. The Bohr model of the hydrogen atom:
(1) What are the postulates of this model? (6%)
(2) Derive from these postulates the energy levels of the electron in the hydrogen atom. (8%)
(3) A gas of hydrogen atoms in their ground state is bombarded by electrons with kinetic energy 12.5 eV. What emitted wavelengths would you expect to see? (6%)

5. Consider a one-dimensional infinite potential energy well of width L:

$$U(x) = \begin{cases} 0 & \text{for } 0 < x < L \\ \infty & \text{elsewhere} \end{cases}.$$

(1) If a particle of mass m is trapped in this potential well, find the energy levels $E_n$ of this particle and the corresponding normalized wavefunctions $\psi_n$ by solving the stationary Schrödinger's equation. (12%)
(2) An electron is trapped in a one-dimensional infinite potential well as described above, with its width L = 200 pm (1 pm = $10^{-12}$ m). Suppose the electron is in its ground state. We position an electron-detector probe of width 2 pm so that it is centered at x = 50 pm. What is the probability of detection by this probe? (8%)
(3) Following (2), now suppose an electron is in a certain excited energy state. The electron's probability density is zero at x = 0.3L and x = 0.4L, while is not zero at intermediate values of x (i.e., 0.3L < x < 0.4L). The electron then jumps to the next lower energy level by emitting light. What is the energy of the emitted photon? (10%)

6. Suppose two electrons in an atom have quantum numbers n = 3 and $l$ = 1, that is, they are both in the 3p subshell.
(1) How many states are possible for these two electrons? (5%)
(2) If the Pauli exclusion principle did not apply to the electrons, how many states would be possible? (5%)

7. Certain atoms in the ground state can absorb radiation at wavelengths 150 nm, 450 nm, 600 nm, and 700 nm. After absorbing radiation at the given wavelengths the atom can radiate at these same wavelengths as well as at additional wavelengths. What are the additional wavelengths? (10%)