1100E04

國立臺北科技大學 110 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 6 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

1. Ultraviolet radiation of wavelength 176 nm is incident on the surface of a metal. Electrons are released from the metal with a maximum kinetic energy of 4.52 eV.
   (1) What is the maximum wavelength of the incident radiation that could cause electrons to be released from the metal? (5%)
   (2) If the wavelength of the incident radiation were changed to 288 nm, what would be the maximum kinetic energy of the emitted electrons? (5%)

2. A special kind of lightbulb emits monochromatic light of wavelength 630 nm. Electrical energy is supplied to it at the rate of 60 W, and the bulb is 93% efficient at converting that energy to light energy. How many photons are emitted by the bulb during its lifetime of 730 hours? (10%)

3. Consider a beam of 54-eV electrons directed at a nickel target. The potential energy of an electron that enters the target changes by 26 eV. Find the de Broglie wavelengths of the electrons outside and inside the target. (10%)

4. An atom has a ground state at an energy 25 eV below ionization. Other levels are at -1.5, -6, and -10 eV. The atom is in the state at -6 eV.
   (1) What wavelengths can be emitted by the atom? (5%)
   (2) What wavelengths can be absorbed by the atom? (5%)

5. Consider a particle of mass m subjected to a one-dimensional potential V(x).
   (1) Please write down the stationary Schrödinger's equation for the particle. Clarify every symbol that you use in the equation.(10%)
   (2) If this particle is confined in an infinite potential well of width a, that is,

$$V(x)=\begin{cases} 0, & 0<x<a \\ \infty, & x<0, x>a \end{cases}.$$

Find the energy levels E_n of this particle and the corresponding normalized wavefunctions ψ_n by solving the Schrödinger's equation. (15%)

   (3) Following (2), if the particle is in a state $\psi = \frac{4}{\sqrt{a}}\sin\frac{\pi x}{a}\cdot\cos^2\frac{\pi x}{a}$, find the detectable energies and the corresponding probabilities. (10%)
   (4) Suppose now the particle is moving in the following potential:

$$V(x)=\begin{cases} \infty, & x<0 \\ 0, & 0<x<a \\ V_0, & x>a \end{cases}.$$

Show that the condition for the existence of at least one bound state of the particle is $V_0 a^2 \geq \frac{h^2}{32m}$, where h is the Planck constant. (15%)

6. Find the minimum magnetic field needed for the (normal) Zeeman effect to be observed in a spectral line of 400-nm wavelength when a spectrometer whose resolution is 0.010 nm is used. (10%)