國立成功大學 109 學年度碩士班招生考試試題

系　　所：光電科學與工程學系

考試科目：近代物理

考試日期：0211，節次：1

※ 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。

Useful constants

Planck constant $h = 6.63 \times 10^{-34}$ J·s ; $e^2/4\pi\varepsilon_0 = 1.44$MeV·fm ; Bohr radius = 0.053 nm ;

Rest energy of electron $m_e c^2 = 0.5$ MeV

1. Radiation of wavelength $\lambda = 290$ nm falls on a metal surface for which the work function is $W = 4.05$ eV. What potential is needed to stop the most energetic photoelectrons? (10%)
2. Consider a wave packet for which

$$A(k) = \begin{cases} N & -K \le k \le K \\ 0 & elsewhere \end{cases}$$

   a) Calculate $\psi(x, 0)$. (5%)

   b) Use a reasonable definition of the width to show that $\Delta k \Delta x > \frac{1}{2}$ is satisfied. (5%)

3. Consider a particle whose normalized wave function is

$$\psi(x) = \begin{cases} 2\alpha\sqrt{\alpha}xe^{-\alpha x} & x > 0 \\ 0 & x < 0 \end{cases}$$

   a) For what value of x does $P(x) = |\psi(x)|^2$ peak? (5%)

   b) Calculate $\langle x \rangle$ and $\langle x^2 \rangle$. (5%)

   c) What is the probability that the particle is found between $x = 0$ and $x = 1/\alpha$? (5%)

   d) Calculate $\phi(p)$ and use this to calculate $\langle p \rangle$ and $\langle p^2 \rangle$. (5%)

4. The wave function for a particle is given by

$$\psi(x) = Ae^{ikx} + Be^{-ikx}$$

   What flux does this represent? (10%)

5. In an electron microscope we wish to study particles of diameter about 0.10 μm.

   a) What should be the de Broglie wavelength of the electrons? (5%)

   b) What potential difference should the electrons be accelerated to have that de Broglie wavelength? (5%)

6. X-ray photons of wavelength 0.02480 nm are incident on a target and the Compton-scattered photons are observed at an angle of 90.0 degrees.

   a) What is the momentum of the scattered photons? (5%)

   b) What is the kinetic energy of the scattered electrons? (5%)

7. In the Rutherford scattering, an α-particle is elastic scattered by a gold nucleus in to angle.

   a) Derive and show the momentum transfer p is: $\Delta p = 2p \sin\frac{\theta}{2}$ (5%)

   b) Calculate the kinetic energy of an α-particle (Z=2) if the distance of closest approach to a gold nucleus (Z=79) is 10 fm, when scattered at 90 degrees. (5%)

8. In the Bohr model of the hydrogen atom, an electron transition occurs from $n = 3$ to n=2.

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a) What is the energy of the emitted radiation? (4%)

b) Compare (a) to the orbital frequency of an electron with $n = 3$ to $n=2$ that it can radiate. (6%)

9. Consider the normal Zeeman effect applied to the $3d$ to $2p$ transition.

a) Sketch an energy level diagram that shows the splitting of the $3d$ and $2p$ levels in an external magnetic field. Indicate all possible transitions from each m_l state of the $3d$ level to each m_l state of the $2p$ level. (5%)

b) How many different transition energies can be emitted? Explain it. (5%)