國　立　清　華　大　學　命　題　紙

96 學年度＿＿＿＿生命科學院＿＿＿＿系（所）＿＿＿＿丙＿＿＿＿組碩士班入學考試

科目＿＿＿＿近代物理＿＿＿＿科目代碼＿0402＿共＿2＿頁第＿1＿頁 *請在【答案卷卡】內作答

1. (10%) Two spaceships, A and B, travel from earth to outerspace. An astronomer on earth observes that A and B travel in opposite directions with the same speed $0.8c$ (c = speed of light). What is the speed of A relative to B ?

2. (10%) A particle with mass m is confined in one-dimensional box between $x = 0$ and $x = L$. Apply the Heisenberg's uncertainty relation to estimate the energy E of this particle at the ground state. Your answer is a function of m, L and the Planck's constant h.

3. (4%) What are the spin angular momentums of a photon and an electron (in unit of $h/2\pi$)?

4. (6%) Explain briefly (a) fermion, (b) quark, and (c) Alpha particle.

5. (10%) Consider a particle of mass m moving in one dimension and the potential energy is

$$V(x) = \frac{1}{2}kx^2.$$

The energy levels of this harmonic oscillator are given by

$$E_n = (n + \frac{1}{2})h\nu$$

where $n = 0, 1, 2, 3, ...$ and

$$\nu = \frac{1}{2\pi}\sqrt{k/m}$$

is the classical frequency of oscillation. If we change the potential energy to $U(x)$ such that $U(x) = V(x)$ for $x > 0$ but $U(x) = \infty$ for $x \leq 0$, what are the energy levels? You should explain how you derive your result.

6. (10%) A photon γ hits an electron at rest, producing an electron-positron pair:

$$\gamma + e^- \rightarrow e^+ + e^- + e^-.$$

Calculate the minimum energy of the incident photon. The electron mass is 0.5 MeV.

7. (10%) The energy levels of the hydrogen atom are

$$E_n = -\frac{13.6}{n^2} eV$$

where $n = 1, 2, 3...$ Calculate the wavelength of the photon emitted when the electron jumps from $n = 2$ state to $n = 1$ state. You need c (speed of light) $=3\times10^8 m/s$, h (Planck's constant) $= 6.6 \times10^{-34} J \cdot s$, $1\ eV = 1.6 \times10^{-19} J$. Write your answer accurate to two significant figures.

8. (30%) Explain (a) Franck-Hertz experiment, (b) Pauli's exclusion principle, (c) Mössbauer effect, (d) Zeeman effect, (e) Meissner effect, and (f) radiocarbon dating.

9. (10%) Write down the steady-state form of Schrödinger's equation in one dimension for a particle with mass m and the potential energy is $U(x)$. Find the wave functions of this particle in a box where

$$U(x) = 0 \qquad 0 < x < L$$

and $U(x) = \infty$ for $x \geq L$ or $x \leq 0$.