

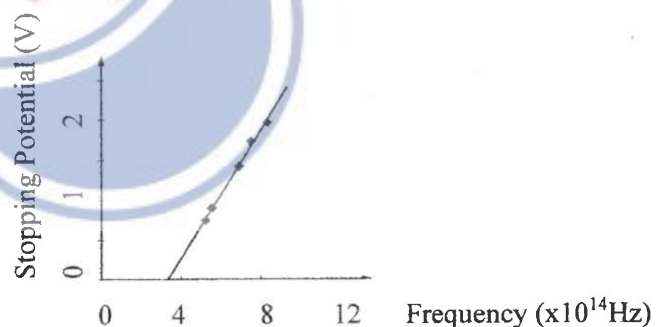
考試科目	近代物理	系所別	應用物理所	考試時間	2月4日(四)第四節
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Planck's constant: $\hbar = 1.06 \times 10^{-34} \text{Js}$, $h = 6.63 \times 10^{-34} \text{Js}$. Speed of light: $c = 3.00 \times 10^8 \text{m/s}$.
 Boltzmann constant: $k_B = 1.38 \times 10^{-23} \text{J/K}$. Charge of electron: $-e = 1.60 \times 10^{-19} \text{C}$.
 Mass of electron: $m_e = 9.11 \times 10^{-31} \text{kg}$. $1\text{J} = 6.24 \times 10^{18} \text{eV}$.

1. [40 points] Short answer questions

- 1.1 [6 points] Describe briefly the Stern-Gerlach experiment for the measurement of the magnetic moments of atoms, and discuss the significance of the results.
- 1.2 [4 points] Explain Larmor precession.
- 1.3 [5 points] Which of the following are characteristics about the quantum harmonic oscillator? Choose all that apply.
- Evenly spaced energy states
 - The potential energy function is symmetric about the origin in the position coordinate
 - The ground state has zero kinetic energy
 - The probability of finding the particle outside the classically allowed range is nonzero
 - The ground state energy is zero
- 1.4 [4 points] For a single quantum harmonic oscillator that has an angular frequency ω . At temperature T , what is the partition function?
- 1.5 [6 points] Write down the distribution function for photons and fermions, respectively.

Questions 1.6 – 1.8 refer to the photoelectric effect and the figure on the right. For an experiment observation, the stopping potential was plotted versus the light frequency, as shown in the figure. The best straight line was fitted to the experimental points.



- 1.6 [4 points] In an experimental observation of the photoelectric effect, does increasing the light amplitude change the stopping potential?
- 1.7 [5 points] What is the physical interpretation of the horizontal intercept?
- 1.8 [6 points] What is physical interpretation of the slope of the line?

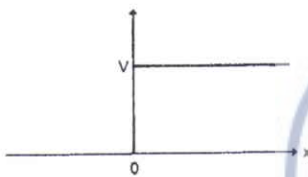
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2. [20 points] A particle in the infinite square well has the wave function, $\psi(x) = \begin{cases} A(x/a), & 0 \leq x \leq a \\ \frac{A(b-x)}{b-a}, & a \leq x \leq b \\ 0, & \text{otherwise} \end{cases}$

2.1 [10 points] Sketch ψ and determine the constant A in terms of a, b .

2.2 [10 points] What is the probability of finding the particle to the left of a ?

3. [10 points] An electron has a speed $v=0.85c$, c is the speed of light. Find its total energy and kinetic energy in electron volts.
4. [10 points] A free particle of mass m and energy E is moving from $x = -\infty$ to $x = \infty$. There is a potential step V , where $V < E$, for $x \geq 0$. Find the transmission and reflection coefficients for the particle in the one-dimensional step potential.



5. [20 points] There are N free electrons in a metal of volume V and the temperature is at absolute zero. It is also known that the distribution of the free electron energy can be described by the density of the electron energy levels $g(\epsilon) = \frac{8\pi V m^{3/2} \sqrt{2\epsilon}}{h^3}$, where ϵ is the (kinetic) energy of the free electron and $g(\epsilon)d\epsilon$ is the number of electronic energy levels (including both spins) between ϵ and $\epsilon + d\epsilon$, m the mass of electron, and h the Planck's constant.
- 5.1 [10 points] Calculate the highest energy level (called Fermi energy) ϵ_f of the electron in the metal in terms of N, V and m .
- 5.2 [10 points] What is the total energy of all the N electrons in the metal as expressed in terms of N and ϵ_f ? What is the average electron energy?

備

註

- 一、作答於試題上者，不予計分。
二、試題請隨卷繳交。