

本試題是否可以使用計算機：可使用，不可使用（請命題老師勾選）

考試日期：0301，節次：1

Physical constants:*Avogadro's number: $N_a = 6.02 \times 10^{23}$ particles/mol**Coulomb constant: $k = 8.987 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$* *Mass of electron: $m_e = 9.1 \times 10^{-31} \text{ Kg}$* *Mass of unit: $u = 1.66 \times 10^{-27} \text{ Kg}$* *Speed of light: $c = 299792458 \text{ m/s}$* *Fine structure constant: $\alpha = 7.297 \times 10^{-3}$* *Permeability of free space: $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$* *Boltzmann's constant: $k = 1.38 \times 10^{-23} \text{ J/K}$* *Fundamental charge: $e = 1.6 \times 10^{-19} \text{ C}$* *Mass of proton: $M_p = 1.67 \times 10^{-27} \text{ Kg}$* *Planck's constant: $h = 6.6 \times 10^{-34} \text{ J} \cdot \text{s}$* *Constant of gravitation: $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{Kg}^2$* *Gas constant: $R = 8.3 \text{ J/mol} \cdot \text{K}$*

1. (10%) Provide a brief qualitative description for each item listed below:
 - (a) Heisenberg uncertainty principle
 - (b) The difference between bosons and fermions
2. (10%) An X-ray photon of wavelength 6pm that collides with an electron is scattered by an angle 90° . (a) What is the change in wavelength of the photon? (b) What is the kinetic energy of the scattered electron?
3. (15%) A particle is confined to a two-dimensional box defined by the following boundary conditions: $V(x,y) = 0$, for $-L/2 \leq x \leq L/2$ and $-3L/2 \leq y \leq 3L/2$; and $V(x,y) = \infty$ elsewhere. (a) Determine the energies of the lowest three bound states. (b) Identify the quantum numbers of the lowest doubly degenerate bound state and determine its energy.
4. (6%) During the photoelectric effect experiment, sodium metal is illuminated with light of wavelength $4.20 \times 10^2 \text{ nm}$. The stopping potential is found to be 0.65 V. When the wavelength is change to be $3.10 \times 10^2 \text{ nm}$, the stopping potential is found to be 1.69 V. The speed of the light, $c = 3.00 \times 10^8 \text{ m/s}$, and the elementary charge, $e = 1.60 \times 10^{-19} \text{ C}$. Find a value for Plank's constant.
5. (9%) An electron is captured in a potential of the form: $V = \infty$ for $x \leq 0$ and for $x \geq a$, $V = 0$ for $0 < x < a/2$ and $V = V_0$ for $a/2 < x < a$. Draw the potential, the wave function for the ground state where $E < V_0$, and the second excited state where $E > V_0$.

(背面仍有題目,請繼續作答)

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6. (10%) Explain the following nouns as clear as possible

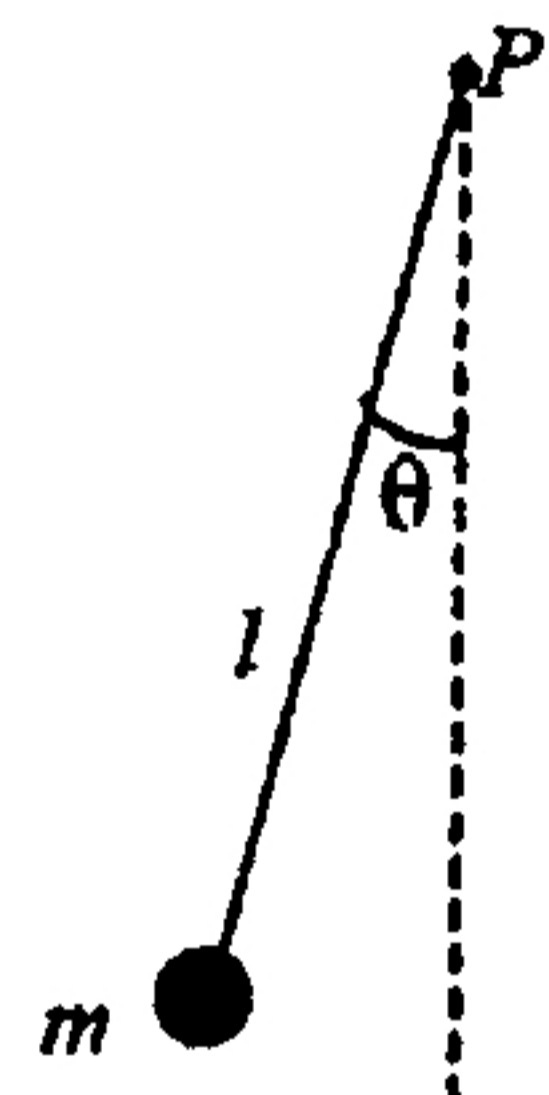
- (a) Pauli exclusion principle.
 (b) Zeeman effect.

7. A particle of mass m moves in one dimension under the influence of a potential $V(x)$. Suppose it is in an energy eigenstate $\psi(x) = (\gamma^2/\pi)^{1/4} \exp(-\gamma^2 x^2/2)$ with energy $E = \hbar^2 \gamma^2/2m$.

- (a) (3%) Find the mean position of the particle.
 (b) (4%) Find the mean momentum of the particle.
 (c) (5%) Find $V(x)$.
 (d) (8%) Find the probability $P(p)dp$ that the particle's momentum is between p and $p+dp$.

8. A mass m is attached by a massless rod of length l to a pivot P and swings in a vertical plane under the influence of gravity (as shown in the figure).

- (a) (5%) In the small angle approximation find the energy levels of the system.
 (b) (5%) Find the lowest order correction to the ground state energy resulting from inaccuracy of the small angle approximation.



9. (a) (5%) What is the quantum mechanical Hamiltonian for a free electron with magnetic moment μ in the external constant magnetic field H_z in the z -direction, in the reference frame of the electron?
 (b) (5%) Suppose that an extra constant magnetic field H_y is imposed in the y -direction. Determine the form of the quantum mechanical operator for the time rate of change of μ in this case.