

系所組別：光電科學與工程學系甲組

考試科目：近代物理

考試日期：0219，節次：1

※ 考生請注意：本試題 可 不可 使用計算機

第一部分選擇題 (40%)：

10 題均為單選題，每題 4 分，答錯不倒扣。不需寫出計算過程，請將選擇題答案整齊書寫在答案卷中，於題目卷中作答不予計分。

- (Relativity) A stationary body explodes into two fragments each of mass 1.0 kg that move apart at speeds of $0.6c$ relative to the original body. Find the mass of the original body.
(A) 0 kg (B) 1.005 kg (C) 2.5 kg (D) 2.01 kg (E) 10 kg
- (Compton Effect) X-rays of wavelength 10.0 pm are scattered from a target. Find the wavelength of the x-rays scattered through 45° , and the maximum wavelength present in the scattered x-rays.
(A) 10.0 pm, 20.0 pm (B) 10.7 pm, 14.9 pm (C) 20.0 pm, 10.0 pm (D) 15.0 pm, 15.0 pm (E) 50.0 pm, 50.0 pm
- (de Broglie Wave) An electron has a de Broglie wavelength of $2.00 \text{ pm} = 2.00 \times 10^{-12} \text{ m}$. Find its kinetic energy.
(A) 620 keV (B) 520 keV (C) 803 keV (D) 292 keV (E) 100 keV
- (Atom structure) An electron collides with a hydrogen atom in its ground state and excites it to a state of $n = 3$. How much energy was given to the hydrogen atom in this inelastic (KE not conserved) collision?
(A) 13.6 eV (B) 7.8 eV (C) 3.9 eV (D) 6.6 eV (E) 12.1 eV
- (Hydrogen Atom) How much more likely is a 1s electron in a hydrogen atom to be at the distance a_0 from the nucleus than at the distance $a_0/2$?
(A) 47 % (B) 53 % (C) 4.7 % (D) 6.6 % (E) 88 %
- (Zeeman shift) A sample of a certain element is placed in a 1-T magnetic field and suitably excited. How far apart are the Zeeman components of the 1- μm spectral line of this element?
(A) $4.66 \times 10^{-11} \text{ m}$ (B) $2.83 \times 10^{-12} \text{ m}$ (C) $6.83 \times 10^{-12} \text{ m}$ (D) $1.22 \times 10^{-10} \text{ m}$ (E) $1 \times 10^{-6} \text{ m}$
- (LS coupling) How many the possible values of the total angular-momentum quantum number J under LS coupling of two atomic electrons whose orbital quantum numbers are $l_1 = 1$ and $l_2 = 2$.
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

(背面仍有題目,請繼續作答)

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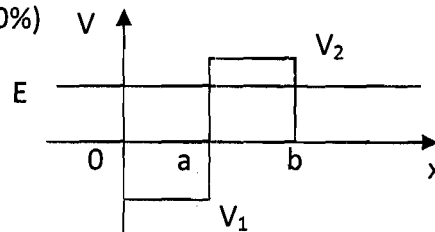
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8. (X-ray Spectra) Which element has a K_{α} x-ray line whose wavelength is 0.180 nm?
(A) ^{27}Co (B) ^{26}Fe (C) ^{19}Fe (D) ^{42}Mn (E) ^{20}Ca
9. (Ideal Gas) Find the rms speed of oxygen molecules at 0 °C.
(A) 461 m/s (B) 361 m/s (C) 303 m/s (D) 222 m/s (E) 621 m/s
10. (Planck Radiation Law) How many photons are present in 1.00 cm³ of radiation in thermal equilibrium at 1000 K?
(A) 2×10^{10} photons (B) 8×10^{10} photons (C) 6×10^{11} photons (D) 7×10^{13} photons (E) 5×10^5 photons

第二部分非選擇題 (60%) :

11. A metal surface illuminated by 8.5×10^{14} Hz light emits electrons whose maximum energy is 0.52 eV. The same surface illuminated by 12.0×10^{12} Hz light emits electron whose maximum energy is 1.97 eV. Please find Planck's constant and work function of metal. (10%)
12. Suppose a proton and an electron were held together in a hydrogen atom by gravitational forces only. Find the formula for the energy levels of such an atom, the radius of its ground state Bohr orbit, and its ionization energy in eV. (10%)
13. For a box
 $V(x,y,z)=0$ for $0 \leq x \leq a$, $0 \leq y \leq b$, and $0 \leq z \leq c$
 $V(x,y,z)=\infty$ otherwise
 (a) What are the normalized eigenfunctions? (b) What are the eigenvalues?
 (c) Find the expectation value of r (d) Find the expectation value of r^2 (e) Find the expectation value of p (f) Find the expectation value of p^2 (g) Find the expectation value of E (h) If $a=b=c=D$ show that $\Delta r \Delta p > \hbar/2$ in the ground state. (10%)
14. Consider the potential barrier as shown in the figure. Please find the transmission coefficient of a particle with energy E . (10%)

$$V(x) = \begin{cases} \infty, & x < 0 \\ -V_1, & 0 < x < a \\ V_2, & a < x < b \\ 0, & b < x \end{cases}$$



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15. (a) Show that Fermi energy at 0K is $E_F = (3\pi^2)^{2/3} \frac{\hbar^2}{2m_e} \left(\frac{N}{V}\right)^{2/3}$ (b) Show that the average energy of an electron is $3E_F/5$ (10%)
16. (a) The magnesium atom has two 3s electron outside filled inner shells. Find the term symbol of its ground state?(5%) (b) The aluminum atom has two 3s and one 3p electron outside filled inner shells. Find the term symbol of its ground state?(5%)

Given constants

Gravitation constant $G=6.673 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$, Permittivity constant $\epsilon_0=8.854 \times 10^{-12} \text{ F/m}$, Permeability constant $\mu_0=1.256 \times 10^{-6} \text{ H/m}$, Boltzmann constant $k=8.617 \times 10^{-5} \text{ eV/K}$, Electron mass $m_e=9.109 \times 10^{-31} \text{ kg}$, Proton mass $m_p=1.673 \times 10^{-27} \text{ kg}$, Planck constant $h=6.626 \times 10^{-34} \text{ J}\cdot\text{s}$