※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

總分共 100 分；選擇題 60 分，非選擇題 40 分

第一大項選擇題總分 60 分；**12 題皆為單選題，*每題答對得 5 分，每題答錯倒扣 1.5 分，該題若不作答則該題以零分計算*，**若總共答對所得的分數小於需要倒扣的分數，則選擇題部分總分以零分計算。**請將選擇題答案整齊書寫於答案卷中，於題目卷中作答將不予計分。**

1. A free particle of kinetic energy (KE) 3eV, traveling in a straight line, approaches a constant higher potential of +2.5eV. The particle will

   (A) have a 100% probability to continue along at KE=0.5 eV.

   (B) be reflected back at the boundary with 100% probability.

   (C) have a 100% probability to decay exponentially in the barrier.

   (D) lose energy in the 2.5 eV region until it stops.

   (E) be partially reflected with KE=3 eV and partially transmitted with KE=0.5 eV.

2. The ground state wavefunction for a particle confined at a one-dimensional box of length L is $\psi = (2/L)^{1/2} \sin(\pi x/L)$. Suppose the length of the box is of 10.0 nm. What is the probability to find the particle between x = 4.9 nm and 5.1 nm?

   (A) 0.01 (B) 0.04 (C) 0.08 (D) 0.1 (E) 0.2

3. How many spectral lines appear in the Zeeman splitting of $^2D_{3/2} \rightarrow {}^2P_{1/2}$ transition of sodium?

   (A) 2 (B) 4 (C) 6 (D) 8 (E) 10

4. What is the wavelength of electrons that have been accelerated from rest through a potential difference of 1.20 kV?

   (A) 3.54×10^{-11} m (B) 4.92×10^{-9} m (C) 1.26×10^{-12} m (D) 5.64×10^{-10} m (E) 8.63×10^{-10} m

(背面仍有題目,請繼續作答)

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5. The H_2^+ molecule (singly ionized) has a ground state electron wavefunction that

(A) collapses from the Coulomb force between the electron and two protons.

(B) is symmetrical with respect to the two protons at fixed separations.

(C) is centered on one proton.

(D) is antisymmetrical with respect to the two protons at fixed separations.

(E) corresponds to ionic bonding.

6. What is the number of photons emitted by a 5 mW laser in 0.5s? Take the wavelength of the laser as 532 nm and assume 20% of efficiency.

(A) 6.23×10^{14} (B) 2.75×10^{15} (C) 1.34×10^{15} (D) 7.06×10^{15} (E) 1.14×10^{16}

7. The wavefunction for two identical spin 1/2 electrons with parallel spin projections ms = +1/2

(A) must vanish when the pair coincide in space.

(B) must be symmetric under the interchange of the electrons.

(C) must distinguish the two electrons from one another.

(D) must represent the probability for the electrons to be interchanged.

(E) must be the simple product of two single electron wavefunctions.

8. The speed of an electron is of 10^5 ms^{-1}. What is the minimum uncertainty in its position?

(A) 3.65 nm (B) 1.52 nm (C) 0.12 nm (D) 0.58 nm (E) 0.06 nm

9. Consider the element ${}_{10}Ne$, its ground state is

(A) $1S^2 1P^6 2S^2$

(B) $1S^2 2S^2 3S^2 3P^4$

(C) $1S^2 2S^2 2P^4 2d^2$

(D) $1S^2 2S^2 2P^6$

(E) $1S^2 3d^8$

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10. In X-ray photoelectron measurement, a photon of wavelength 135 pm ejects an electron from the inner shell of an atom and it emerges with a speed of 2.0×10^7 ms-1. What is the binding energy of the electron?

(A) 5.23 fJ (B) 0.15 fJ (C) 2.35 fJ (D) 3.56 fJ (E)1.29 fJ

11. A particular crystalline solid has an energy gap of 5.0eV between the valance band and the nearest conduction band. At $T \cong 0K$ the valence band is filled and the conduction band is empty. At room temperature ($T \cong 300K$)

(A) many electrons will be in the conduction band making this a semiconductor.

(B) many electrons will be in the conduction band making this an insulator.

(C) very few electrons will be in the conduction band making this a semiconductor.

(D) the valence and conduction bands will overlap making this like a metal.

(E) few electrons will be in the conduction band making this an insulator.

12. In an experiment on the Compton scattering of X-rays by electrons, the incident beam has wavelength 50.44 pm. What is the maximum wavelength of the scattered X-ray?

(A) 55.30 pm (B) 56.84 pm (C) 51.34 pm (D) 49.75 pm (E) 54.23 pm

第二大項為非選擇題總分 40 分，請將答案依序整齊書寫於答案卷中，於題目卷中作答將不予計分。

13. (10 分) (a) Consider the LS coupling, what are the ground state and the first excited state of a sodium atom? (b) When a sodium atom is placed in a weak magnetic field B, calculate the longest wavelengths of the electric dipole induced transition from the first excited state to the ground state.

14. (5 分) Please define and explain the effective mass of an electron in a semiconductor crystal.

(背面仍有題目,請繼續作答)

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15. (10 分)名詞解釋

(A) Lande interval rule

(B) Cooper pair

16. (5 分) Please define and explain Blackbody radiation? (2 分) Please give an example.

17. (8 分) Consider an electron with the energy of 6.0 eV impinging on a potential barrier with 10 eV. The tunneling probability is calculated to be 4.5×10^{-5}. Please estimate the width of the barrier.

Quantity	Symbol/Unit	Value
Angstrom unit	Å	1 Å = 10^{-1} nm = 10^{-4} μm = 10^{-8} cm = 10^{-10} m
Avogadro constant	N_{AVO}	6.02204×10^{23} mole^{-1}
Bohr radius	a_B	0.52917 Å
Boltzmann constant	k	1.38066×10^{-23} J/K (R/N_{AVO})
Elementary charge	q	1.60218×10^{-19} C
Electron rest mass	m_0	0.91095×10^{-30} kg
Electron volt	eV	1 eV = 1.60218×10^{-19} J = 23.053 kcal/mole
Gas constant	R	1.98719 cal/mole−K
Permeability in vacuum	μ_0	1.25663×10^{-8} H/cm ($4\pi\times10^{-9}$)
Permittivity in vacuum	ϵ_0	8.85418×10^{-14} F/cm ($1/\mu_0c^2$)
Planck constant	h	6.62617×10^{-34} J-s
Reduced Planck constant	$\hbar$	1.05458×10^{-34} J-s ($h/2\pi$)
Proton rest mass	M_p	1.67264×10^{-27} kg
Speed of light in vacuum	c	2.99792×10^{10} cm/s
Standard atmosphere		1.01325×10^{5} Pa
Thermal voltage at 300 K	kT/q	0.0259 V
Wavelength of 1-eV quantum	λ	1.23977 μm