科目：近代物理(500H)　　　　校系所組：中大照明與顯示科技研究所(乙組)
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單選題共十題, 一題 5 分, 答錯倒扣 1.25 分. 複選題共十題, 一題 5 分, 單一選項答錯倒扣 1 分.

Part I. (單選題)

1. Consider the energy quantization of a particle confined in an infinite potential well. Which of the following statements is true?
   (A) The lighter the particle mass, the weaker the energy quantization.
   (B) The wider the potential well, the stronger the energy quantization.
   (C) The wider the potential well and the heavier the particle mass, the weaker the energy quantization.
   (D) The heavier the particle mass, the stronger the energy quantization.

2. Consider the binding energy of electron in a hydrogen atom within the Bohr model. Which of the following is true?
   (A) The binding energy decreases with increasing the electron mass.
   (B) The binding energy decreases with increasing the electron charge .
   (C) The binding energy increases with increasing the electron mass and increasing the electron charge.
   (D) The binding energy decreases with decreasing the vacuum dielectric constant.

3. Carbon (diamond) and silicon have the same covalent crystal structure, yet diamond is transparent while silicon is opaque to visible light (wavelength ranging from 400 nm to 750 nm). This effect is due to which of the following reasons?
   (A) Diamond has a much greater band gap than silicon does.
   (B) Diamond has less valence electrons.
   (C) Diamond is harder than silicon.
   (D) Silicon has more crystalline defects and impurities.
   (E) Silicon has better electrical conduction.

4. A stationary muon μ_- annihilate with a stationary antimuon μ_+ (same mass, 1.88×10^{-28} kg, but opposite charge). Which of the following statements is correct?
   (A) A single photon can result, with wavelength $\lambda = 2.36\times10^{-14}$ m.
   (B) A single photon can result, with wavelength $\lambda = 1.18\times10^{-14}$ m.
   (C) Two photons moving in arbitrary directions can result.
   (D) The energy of each resulting photon must equal the mass energy of a muon.
   (E) None of the above.

5. The average intensity of an electromagnetic wave is $(1/2)\varepsilon_0 c E_0^2$, where E_0 is the amplitude of the electric field portion of the wave. Find the correct expression for the photon flux j (measured in photons/sec-m^2) in terms of E_0 and wavelength λ.
   (A) $\dfrac{\varepsilon_0 E_0^2 \lambda}{2h}$ (B) $\dfrac{2hc}{\varepsilon_0 E_0^2 \lambda}$ (C) $\dfrac{\varepsilon_0 c E_0^2 \lambda}{4h}$ (D) $\dfrac{4hc}{\varepsilon_0 E_0^2 \lambda}$ (E) $\dfrac{c E_0^2 \lambda}{4h}$

注意：背面有試題

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6. For a particle of mass m moving in a potential $U(x)$, its eigenvalues are $E_n = \hbar\omega_0(n+\frac{1}{2})$ where $\hbar$ denotes the Planck constant. ω_0 is the frequency of oscillation. $n = 1,3,5,7,9\ldots$ .The potential $U(x)$ is

(A) $U(x) = \begin{cases} \infty, x \le 0 \\ \frac{1}{2}m\omega_0^2 x^2 \end{cases}$, (B) $U(x) = \frac{1}{2}m\omega_0^2 x^2$, (C) $U(x) = \begin{cases} 0, x \le 0 \\ \frac{1}{2}m\omega_0^2 x^2 \end{cases}$, and (D) $U(x) = \mathrm{eF}x$,

where e and F denote, respectively, the charge of particle and the applied electric field F.

7. Energies of stationary states of hydrogen atom with zero angular momentum in three dimensional space are quantized as $E_n = -\frac{1}{n^2}R_y$ (n=1,2,3…) and R_y is the Rydberg energy. The eigenenergies of two-dimensional hydrogen atom with zero angular momentum are given by

(A) $E_n = -\frac{1}{n}R_y$ (n=1,2,3..),(B) $E_n = -\frac{1}{n^2}R_y (n = 1,2,3..)$,(C) $E_n = -\frac{1}{(n-1/2)^2}R_y$ (n=1,2,3..)

(D) $E_n = -\frac{1}{n^3}R_y$.(n=1,2,3..)

8. Density of states $\rho(E)$ is defined as the number of available states per unit energy interval, the $\rho(E)$ of three-dimensional free electron gas is in proportion to
(A) $E^{-1/2}$, (B) E^0, (C) $E^{1/2}$, (D) $\ln E$

9. Consider an electron confined in a two-dimensional square box, with each side being L. What is the ground state energy of the electron

(A) 0, (B) $h^2/(8mL^2)$, (C) $2h^2/(8mL^2)$, (D) $3h^2/(8mL^2)$,

where h = Planck's constant, and m = electron mass.

10. For the quantum oscillator, the minimum allowed energy level is
(A) $\frac{3}{2}\hbar\omega$, (B) $\hbar\omega$, (C) 0 ,(D) $\frac{1}{2}\hbar\omega$,
where $\hbar$ is the reduced Planck's constant and ω is the angular frequency of the simple harmonic vibration.

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Part II. (複選題)

11. Which of the following are quantum phenomena (which do not exist in classical mechanics)?
    (A) Tunneling of a particle through a barrier.
    (B) Reflection of an incident particle at the interface of a step potential even when the particle has energy higher than the barrier.
    (C) Bonding of electrons to a nucleus.
    (D) Existence of energy gaps in semiconductors.

12. Which of the following statements are true concerning the quantization of angular momentum in a spherical symmetric system? Let L = the magnitude of angular momentum.
    (A) The magnitude of angular momentum is a good quantum number only in spherical symmetric systems.
    (B) The maximum z-component of the angular momentum is also L.
    (C) The projection of angular momentum onto a given direction can be any value as long as it is between –L and L.
    (D) Spin is a type of angular momentum.

13. Which of the following statements are true concerning the symmetry of wave function of a two-quantum particle system?
    (A)If the two particles are different species, the wave function still has to obey exchange symmetry.
    (B) If the two particles are identical, the wave function must obey exchange symmetry.
    (C) If the two particles are up-spin electrons, the wave function must be antisymmetric.
    (D) If the two particles are identical bosons, the wave function must be symmetric.

14. Which of the following statements are true?
    (A) The fundamental difference between an insulator and a conductor is whether the highest band occupied by electrons is completely or only partially full.
    (B) Lithium (Z=3) is a conductor because the 2*s* band in lithium is only half full, while beryllium (Z=4) is an insulator because the 2*s* band is completely full.
    (C) At absolute zero temperature, a semiconductor has the same Fermi-Dirac distribution with a conductor.
    (D) At nonzero temperature, the Fermi-Dirac distribution of a semiconductor deviates from a step function symmetrically about the valence band edge. (E) In an intrinsic (undoped) semiconductor, electrical conduction at room temperature is attributed mainly to electron flow in the conduction band.

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15. Imagine a beam of monoenergetic electrons striking a barrier with two identical narrow slits separated by 40 nm, beyond which is a screen that registers each electron's arrival by producing a small flash. At the center detector, directly in the path the beam would follow if unobstructed, 400 electrons per second are detected. Which of the following statements are true?
(A) If one of the slits is blocked, we find electrons registering sporadically over the entire screen.
(B) If both slits are open, we can use quantum mechanics to predict with certainty where a given particle will be found.
(C) If one of the slits is blocked, the electron detection rate would be 200 s^{-1} at the center detector.
(D) If one slit is narrowed so that it alone would give a count rate 36% of its original value, the electron detection rate would be 144 s^{-1} at the center detector.
(E) Following the condition in question (D), the electron detection rate would be 16 s^{-1} at the first minimum.

16. Which of the following statements are not true according to blackbody radiation?
(A) Quantization of electromagnetic radiation,
(B) Photons satisfy the boson distribution function,
(C) Ultraviolet catastrophe occurs
(D) the intensity of blackbody radiation does not depend on temperatures.

17. Which of the following statements are true?
(A) Electrons obey the Fermi statistics.
(B) Photons obey the Boltzmann statistics.
(C) Phonons obey the Boson statistics.
(D) Neutrinos obey the Boson statistics.

18. Which of the following statements are not correct?
(A)The p orbitals of hydrogen atoms are the six-fold degeneracy if including electron spin.
(B) The transition behavior of electrons in atomic energy levels can be explained by the classical mechanics.
(C) Electrons do not collapse into positive nucleus as a result of their stationary states.
(D)The distribution function employed to describe free electrons in equilibrium is given by $f(E)=\frac{1}{e^{\frac{E-\mu}{k_BT}}+1}$, where μ is the particle number-independent chemical potential, k_B is the Boltzmann constant, and T is temperature.

19. About the Compton effect, which statements in the following are correct?
(A)The Compton wavelength of the electron is $\frac{h}{m_e c^2}$, where h is the Planck's constant, m_e is the electron's mass, and c is the speed of light.
(B) It proves that the light behaves like particles.
(C) It proves that the light behaves like wave.

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(D) The scattered X-ray has the wavelength λ' to be $\lambda_0 + \frac{h}{m_e c}(1- \cos\theta)$, where λ_0 is the wavelength of the incident X-ray and θ is the scattered angle of the X-ray from the incident direction.

20. About the Bohr's quantum model of the hydrogen atom, which following items are incorrect .

(A) The Bohr radius a_0 is $\frac{h^2}{4\pi^2 m_e k e^2}$, where m_e is the electron's mass, k is Coulomb constant, e is the elementary charge of electron, and h is the Planck's constant.

(B) The allowed energy levels have the quantized energy values to be $-\frac{ke^2}{4a_0}(\frac{1}{n^2})$, where n are the integral quantum numbers.

(C) The ionization energy for hydrogen is $\frac{ke^2}{8a_0}$.

(D) The Balmer's empirical relation is $\frac{ke^2}{2a_0 hc}(\frac{1}{4}-\frac{1}{n^2})$, where $n=$ 3, 4, 5 , ...and c is the speed of light.

Fundamental constants

1. Electron charge $e = 1.6 \times 10^{-19} C$
2. Planck's constant $h = 6.625 \times 10^{-34} J \cdot s$
3. Speed of light $c = 3.0 \times 10^{8} m/s$
4. Electron mass $m_e = 9.1 \times 10^{-31} kg$
5. Boltzmann's constant $k_B = 1.38 \times 10^{-23} J/K$