類組：物理類　　科目：近代物理(2003)　　※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

台灣聯合大學系統近代物理試題

一、多重選擇題，使用答案卡(每題 5 分，共 20 分，每題單一選項答錯倒扣 1 分)

1. Which two are the postulates of Einstein's special relativity?
   (A) The laws of physics are the same in all the inertial frames of reference.
   (B) The speed of light in free space is the maximum possible speed in the universe.
   (C) Mass can be transformed into energy completely.
   (D) The speed of light in free space has the same value in all inertial frames of reference.
   (E) The definition of time relies on the reference frame.

2. Which statements are not true regarding photoelectric effect?
   (A) There is no detectable time interval between the arrival of light at metal surface and the emission of photoelectrons.
   (B) A bright light yields more photoelectrons than a dim one of the same frequency.
   (C) A bright light yields photoelectrons of higher energies than a dim one of the same frequency.
   (D) The higher the frequency of the light, the more energy the photoelectrons have.
   (E) This effect can be explained by the classical electromagnetic wave theory of light.

3. Which statements are true?
   (A) According to quantum mechanics, it is impossible to determine the precise values of any two different physical quantities simultaneously.
   (B) Photons are bosons.
   (C) Hydrogen atom has only discrete spectrum of energy.
   (D) Harmonic oscillator system has discrete as well as continuous energy spectrum.
   (E) The square of the absolute value of wave function represents probability density.

4. Which effects or phenomena reveal the particle nature of light?
   (A) Aharonov-Bohm effect   (B) Compton effect   (C) Doppler effect   (D) Photoelectric effect   (E) Gravitational red shift

二、單一選擇題，使用答案卡(每題 5 分，共 70 分。每題答錯倒扣 1 分)

5. Which physical quantity is invariant under Lorentz transformation?
   (A) energy   (B) momentum   (C) current   (D) charge density   (E) charge

注意：背面有試題

參考用

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6. Which action cannot increase the ground state energy of a finite potential well ?
   (A) decrease the well width
   (B) increase the well width
   (C) increase the high (the potential outside) of the well
   (D) reduce the mass of the particle that is confined in the well
   (E) increase the value of Planck constant (if it is possible)

7. A particle is confined in a cubic box with walls unable to penetrate. The edges of the walls have length L. Which statement is not correct?

   (A) the energy levels are of the form $E = \frac{1}{3} E_0 \left(n_1^2 + n_2^2 + n_3^2 \right)$, where n_1, n_2, n_3 are three positive integers, and E_0 is the ground state energy.

   (B) the eigen-wavefunctions of the time independent Schrödinger equation can be expressed as $u(x, y, z) = A \sin \frac{n_1 \pi x}{L} \sin \frac{n_2 \pi y}{L} \sin \frac{n_3 \pi z}{L}$ if the coordinate axes are coincident with three edges of the box. Here A is the normalization constant.

   (C) the degeneracy of the ground state is 1.

   (D) the ground state energy is $E_0 = \frac{3\pi^2 \hbar^2}{2mL^2}$.

   (E) if two opposite walls are replaced by a parabolic potential, the energy levels would become $E = E_a \left(n_1^2 + n_2^2 \right) + E_b n_3$, where n_1, n_2, n_3 are three positive integers, E_a and E_b are two constant energies.

8. Choose the fact or phenomenon that has nothing to do with uncertainty principle.
   (A) the quantization of angular momentum in a central potential.
   (B) zero point energy of the harmonic oscillator system.
   (C) the precise location of a particle under Brownian motion is unpredictable
   (D) the exact position and exact momentum of an object cannot be determined at the same time.
   (E) the uncertainty of the measured energy ΔE in an atomic process times the uncertainty of time Δt of the measurement must be equal to or greater than $\hbar / 2$.

9. An electron is located at orbital 3p, which of the following orbital this electron can't achieve transition by emitting or absorbing a photon? (A) 2p, (B) 4s, (C) 3s, (D) 5d, (E) 5s.
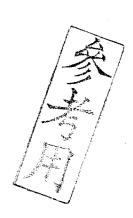
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10. Melting point of a piece of material is related to the
    (A) ionization energy of the composite atoms,
    (B) bonding energy between the atoms,
    (C) Debye energy of the material,
    (D) spin-orbital interaction of the electron states,
    (E) mean free path of the free electrons.

11. To describe the collective behavior of a large number of photon should use (A) Boltzman distribution, (B) Fermi-Dirac distribution, (C) Bose-Einstein distribution, (D) probability distribution, (E) Gaussian distribution.

12. When temperature increases, which of the following statement is false?
    (A) Electric conductivity of metal decreases.
    (B) Fermi-Dirac distribution gets closer to Boltzman distribution.
    (C) Lattice constants of most crystals increase.
    (D) Peak emission wavelength of black body radiation increases.
    (E) Electron has better chance to tunnel through a finite thickness potential barrier.

13. The so-called K_β X-ray is originated from the transition of (A) n=4 $\rightarrow$ n=2, (B) n=2 $\rightarrow$ n=1, (C) n=3 $\rightarrow$ n=2, (D) n=3 $\rightarrow$ n=1, (E) n=5 $\rightarrow$ n=2.

14. An electron has two energy states with wave functions are ψ_1 and ψ_2. If
    $$\int_{-\infty}^{\infty} x\psi_1\psi_2^* dV = 0,$$ this implies that
    (A) the two states are anti-symmetry,
    (B) the transition probability of the electron between these two states are 0,
    (C) the two states are allowed transition,
    (D) the two states have parallel spin direction,
    (E) these two states are orthogonal to each other.

15. The magnesium (Mg) atom has two 3s electrons outside filled inner shells. The term symbol of its ground state is (A) $^2P_{1/2}$, (B) $^1S_0$, (C) $^2P_{5/2}$, (D) $^2S_{1/2}$, (E) $^3P_{1/2}$.

16. When temperature increases, which of the following statement is false?
    (A) Electric conductivity of metal decreases.
    (B) Fermi-Dirac distribution gets closer to Boltzman distribution.
    (C) Lattice constants of most crystals increase.
    (D) Peak emission wavelength of black body radiation increases.
    (E) Electron has better chance to tunnel through a finite thickness potential barrier.

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17. An electron has wavefunction of ψ. If a positive charge q is located at the origin. The potential energy of the electron can be written as (A) $kqe\int_{-\infty}^{\infty} r\psi\psi^* dr$. (B)

$\dfrac{kqe}{\int_{-\infty}^{\infty}\psi\psi^* dV}$. (C) $\dfrac{kq}{r^2}\int_{-\infty}^{\infty} e\psi\psi^* dV$. (D) $\dfrac{kqe}{\left(\int_{0}^{\infty} r\psi\psi^* dr\right)^2}$. (E) $\dfrac{kqe}{\int_{0}^{\infty} r\psi\psi^* dV}$.

18. Which of the following statements about Zeeman effect is incorrect?
    (A) It describes how atoms interact with a magnetic field.
    (B) Electron spin can cause the spectral splitting of an atom in a magnetic field.
    (C) Electron with larger orbital quantum number gives more splitted energy levels of an atom in a magnetic field.
    (D) Electron with larger magnetic quantum number gives less splitted energy levels of an atom in a magnetic field.
    (E) Normal Zeeman effect did not consider electron spin.

三、填充題 (共兩題，每題 5 分，共 10 分)，請將答案填寫在試卷紙上 (不必寫計算過程)

19. A quantum system has only two energy levels E_1, E_2, and there is no degeneracy. Suppose initially the system is in a superposition state described by the initial wave function $\psi(x,0)=\dfrac{1}{\sqrt{2}}u_1(x)+\dfrac{i}{\sqrt{2}}u_2(x)$, here $u_1(x)$ and $u_2(x)$ are the normalized eigen-functions of the system Hamiltonian, and E_1 and E_2 are the corresponding eigenvalues respectively. Please give the result of the wave function $\psi(x,t)$ at a later time t.

20. Which one is the correct definition of force acting on a point particle of rest mass m, according to Einstein's special relativity?

    (1) $\mathbf{F}=\gamma m\mathbf{a}$　(2) $\mathbf{F}=\dfrac{d}{dt}(\gamma m\mathbf{v})$

    Here $\mathbf{F}$ denotes the force, $\mathbf{v}$ is the velocity of the particle, $\mathbf{a}$ represents the acceleration, $\gamma=\dfrac{1}{\sqrt{1-v^2/c^2}}$ is factor determined by the ratio v/c, and c is the speed of light in free space.

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