國 立 清 華 大 學 命 題 紙

96 學年度 電機領域聯合招生 系（所） 組碩士班入學考試

科目 近代物理 科目代碼 9912 共 5 頁第 1 頁 *請在【答案卷卡】內作答

單選題，總共二十題，答對一題五分，答錯一題倒扣 1.25 分

1. In the hydrogen atom, which of the following statements is incorrect?
   (A) The angular momentum L never aligns with its z-component L_z.
   (B) We know nothing at all about L_x and L_y, whenever L_z is determined.
   (C) The space quantization is due to the fact that only certain orientations of angular momentum vectors are allowed.
   (D) For the quantum state n=1, l=0, and m_l=0, the total probability density has nothing to do with the angular probability density.
   (E) Compare the 1s with the 2s states, the 1s state has smaller maximum of radial probability density.

2. Which of the following statements is incorrect?
   (A) The Fermi-Dirac distribution is written as $f(E) = \dfrac{1}{Ae^{E/kT}+1}$.
   (B) At zero temperature, the Fermi-Dirac distribution function is a Heaviside step function.
   (C) In cavity radiation, the emitted light obeys the Fermi-Dirac distribution.
   (D) Particles that do not obey the Pauli principle are those with integral spins and are known as bosons.
   (E) The presence of a boson in a particular quantum state enhances the probability that the other identical bosons will be found in the same state.

3. A beam of hydrogen atoms is prepared in the n=2, l=1 state. The beam consists of equal numbers of atoms in the m_l=-1, 0, and +1 states. We do the Stern-Gerlach type experiment in which a "uniform" magnetic field is applied. How many lines on the collector plate can be observed?
   (A) 6 (B) 4 (C) 3 (D) 2 (E) 1

4. An electron with energy E tunnels through a rectangle energy barrier which is U_0 in height and a_0 in width. Which of the following statements is correct?
   (A) The wavelength of the electron is different on both sides of the barrier.
   (B) The particle cannot be observed beyond the barrier for $E<U_0$.
   (C) The intensity of transmitted wave for $E<U_0$ depends on the E, U_0, and a_0.
   (D) The electron loses part of its energy during the tunneling.

(E) None of the above.

5. The ground state energy of an oscillating electron is 1.32 eV. How much energy must be added to the electron to move it to the second excited state?
(A) 3.96 eV (B) 5.28 eV (C) 7.60 eV (D) 8.92 eV (E) 10.24 eV

6. A particle is confined to a two-dimensional box of length L and width $2L$. The energy values are $E = E_0(n_x^2 + n_y^2/4)$ with $E_0 = \hbar^2\pi^2/2mL^2$. Find the energy of the lowest degenerate levels.
(A) $E = 5.00E_0$ (B) $E = 6.25E_0$ (C) $E = 7.25E_0$ (D) $E = 8.00E_0$ (E) $E = 10.00E_0$

7. A particle is trapped in an infinite one-dimensional well of width L. If the particle is in its ground state, evaluate the probability to find the particle between x=0 and x=L/3.
(A) $\frac{1}{3}-\frac{\sqrt{3}}{2\pi}$ (B) $\frac{1}{3}-\frac{\sqrt{3}}{4\pi}$ (C) $\frac{2}{3}-\frac{\sqrt{3}}{\pi}$ (D) $\frac{2}{3}-\frac{\sqrt{3}}{2\pi}$ (E) $\frac{2}{3}-\frac{2\sqrt{3}}{\pi}$

8. The first excited state of sodium decays to the ground state by emitting a photon of wavelength 590 nm. If sodium vapor is used for the Franck-Hertz experiment, at which voltage will the first current drop be observed?
(A) 1.90 V (B) 2.10 V (C) 2.70 V (D) 3.10 V (E) 3.30 V

9. Consider the n=2, l=1 energy states of hydrogen. A magnetic field B is applied in a direction that we define to be the z-direction. How many fine structures can we observe?
(A) 6 (B) 5 (C) 4 (D) 3 (E) 2

10. Which of the following statements concerning the atomic model is incorrect?
(A) The "plum-pudding" model proposed by J. J. Thomson had remarkable discrepancy with Rutherford's experimental results.
(B) Bohr came up with the idea of stationary states, in which the electron may exist without radiating electromagnetic energy.
(C) The Bohr model is useful only for atoms that contains one electron, but not for atoms with two or more electrons.
(D) Bohr kept the uncertainty relationship valid in his model.
(E) The Bohr model gives incorrect predictions for the angular momentum of the

electron.

11. Given the following wave function $\psi(x) \propto \sin(k^2 x)/x$ for a particle, what are the position resolution , Δx , and momentum resolution, Δp , of the particle? Let h = Planck constant. Then,

(A) $\Delta x \sim 1/k$, $\Delta p \sim h\,k$

(B) $\Delta x \sim 1/k^2$, $\Delta p \sim h\,k^2$

(C) $\Delta x \sim 1/k^2$, $\Delta p \sim h\,k$

(D) $\Delta x \sim 1/k$, $\Delta p \sim h\,k^2$

(E) None of the above.

12. Consider a particle confined in a one-dimensional symmetric potential well, and let one of its energy eigenstates be $\psi(x)$. Which of the following statements is true regarding this state?

(A)The corresponding current density is non-zero.

(B)The wavefunction cannot be real-valued.

(C)The probability density $|\psi(x)|^2$ must be symmetric.

(D)The wavefunction $\psi(x)$ must be symmetric.

(E)None of the above.

13. Which of the following statements is consistent with the correspondence principle?

(A)Quantum states with small quantum number approach classical limit.

(B)Quantum systems with small length scale approach classical limit.

(C) Quantum systems at low temperature approach classical limit.

(D)Quantum states with short wavelength approach classical limit.

(E)None of the above.

14. Consider two electrons. Which of the following statements is consistent with Pauli exclusion principle?

(A)If the two electrons have antiparallel spin, they are forbidden to appear at the same place.

(B)If the two electrons have parallel spins, they tend to stay away from each other.

(C)If the two electrons have antiparallel spin, they are forbidden to occupy the same quantum orbit.

(D)If the two electrons have parallel spins, they can occupy the same quantum orbit.

(E)None of the above.

15. Semiconductors are insulators with energy gaps, and their device application mostly depends on gaps and doping. Which of the following statements is wrong?
(A)The gap separates conduction band from valence band.
(B)The gap would still be nonzero if electrons were classical particles.
(C)A P-type semiconductor at finite temperature has partially filled conduction band.
(D)An undoped semiconductor at zero temperature has empty conduction band.
(E)An undoped semiconductor at finite temperature has conduction and valence bands both being partially filled.

16. About blackbody radiation, which statement is incorrect: (A) the results can not be applied to the situation of thermal non-equilibrium (B) the peak radiation wavelength can be obtained if one knows the absolute temperature (C) Planck's hypothesis is necessary to explain the experimental data (D) the total power per unit area emitted at all frequencies is proportional to the square of the absolute temperature (E) it is possible to view a body in dark by observing its blackbody radiation.

17. In the photo-electric effect, which statement is incorrect: (A) a threshold voltage is needed to start the photo-current (B) the kinetic energy of the ejected electron is independent on the light frequency (C) the photo-current increasing with the increasing light intensity (D) there is almost no time lag between the start of illumination and the start of the photo-current (E) the photo-electric effect reveals the energy quantization of radiation.

18. Which of the following effect is not governed by quantum mechanical tunneling effect: (A) electrical conduction through a CuO insulator film (B) electron emission from a metal by the application of a strong electric field (C) decay of black hole (D) the position inversion of the nitrogen atom in the ammonia molecule (E) normal Zeeman effect.

19. There is a certain width in the frequency distribution of the spontaneous emission between two energy levels, it is governed by (A) Heisenberg's uncertainty principle (B) life time of spontaneous emission is infinite (C) the selection rules of the atomic transition (D) Pauli exclusion principle (E) None of the above.

20. About Copenhagen interpretation of quantum mechanics, which of the following statement is correct: (A) Einstein-Podolsky-Rosen paradox is in favor of the Copenhagen interpretation (B) The square of wavefunction can also be successfully interpreted as electron density instead of probability density as was originally proposed by Schrodinger (C) the dynamic variable is not exactly known until the measurement is performed (D) the possible measured value of the observables is not limited to its corresponding eigenvalues (E) Any measurable variable is not necessarily be represented by a mathematical operator.

Planck's constant $h = 6.626\times10^{-34}\ \text{J}\cdot\text{s} = 4.135\times10^{-15}\ \text{eV}\cdot\text{s}$

Reduced Planck's constant $\hbar = 1.054\times10^{-34}\ \text{J}\cdot\text{s} = 6.582\times10^{-16}\ \text{eV}\cdot\text{s}$

Speed of light $c = 2.99\times10^{-8}\ \text{m/s}$