國立成功大學

112學年度碩士班招生考試試題

編　號：39

系　所：物理學系

科　目：近代物理學

日　期：0207

節　次：第 3 節

備　註：不可使用計算機

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※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

e = 1.60 x 10^{-19} coulomb;　h = 6.63 x 10^{-34} joule•second;　1Å= 1 x 10^{-10} meter

每題 5 分，不倒扣，共 100 分

1. Lattice forces affect the motion of electrons in a metallic crystal, so that the relationship between the energy E and wave number k is not the classical equation $E = h^2k^2/2m$, where m is the electron mass. Instead, it is possible to use an effective mass m^* given by which of the following?

   (A) $m^* = \frac{1}{2}\hbar^2 k(\frac{dk}{dE})$　(B) $m^* = \hbar^2 k/(\frac{dk}{dE})$　(C) $m^* = \hbar^2 k(\frac{d^2k}{dE^2})^{\frac{1}{3}}$

   (D) $m^* = \hbar^2/(\frac{d^2E}{dk^2})$　(E) $m^* = \frac{1}{2}\hbar^2 m^2(\frac{d^2E}{dk^2})$

2. The matrix $A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 1 & 0 & 0\end{bmatrix}$ has three eigenvalues λ_i defined by $AV_i = \lambda_i V_i$. Which of the following statements is NOT true?

   (A) $\lambda_1 + \lambda_2 + \lambda_3 = 0$　(B) λ_1, λ_2, and λ_3 are all real numbers　(C) $\lambda_2\lambda_3 = +1$ for some pairs of roots　(D) $\lambda_1\lambda_2 + \lambda_2\lambda_3 + \lambda_1\lambda_3 = 0$　(E) $\lambda_i^3 = +1,\ i = 1,2,3$

3. A particle of mass M moves in a circular orbit of radius r around a fixed point under the influence of an attractive force $F = K/r^3$, where K is a constant. If the potential energy of the particle is zero at an infinite distance from the force center, the total energy of the particle in the circular orbit is

   (A) $-K/r^2$　(B) $-K/2r^2$　(C) 0　(D) $K/2r^2$　(E) K/r^2

4. The particle decay $\Lambda \rightarrow p + \pi^-$ must be a weak interaction because

   (A) the π^- is a lepton　(B) the Λ has spin zero　(C) no neutrino is produced in the decay

   (D) it does not conserve angular momentum　(E) it does not conserve strangeness

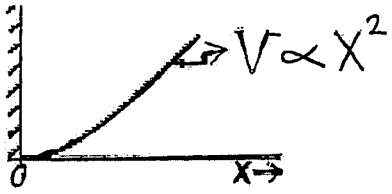
5. The energy levels for the one-dimensional harmonic oscillator are $h\nu(n+\frac{1}{2})$, n = 0, l, 2 ....

   How will the energy levels for the potential shown in the graph below differ from those for the harmonic oscillator ($x \leq 0$ with an infinite barrier)?

   (A) The term $\frac{1}{2}$ will be changed to $\frac{3}{2}$.　(B) The energy of each level will be doubled.

   (C) The energy of each level will be halved.　(D) Only those for even values of n will be present.

   (E) Only those for odd values of n will be present.



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6. A free electron (rest mass m_e = 0.5 MeV/c^2) has a total energy of 1.5 MeV. Its momentum p in units of MeV /c is about
   (A) 0.86 (B) 1.0 (C) 1.4 (D) 1.5 (E) 2.0
7. A beam of electrons is accelerated through a potential difference of 25 kilovolts in an x-ray tube. The continuous x-ray spectrum emitted by the target of the tube will have a short wavelength limit of most nearly
   (A) 1.0 Å (B) 0.5 Å (C) 2 Å (D) 25 Å (E) 50 Å
8. The configuration of three electrons ls2p3p has which of following as the value of its maximum possible total angular momentum quantum number?
   (A) $\frac{7}{2}$ (B) 3 (C) $\frac{5}{2}$ (D) 2 (E) $\frac{3}{2}$
9. Consider a heavy nucleus with spin $\frac{1}{2}$. The magnitude of the ratio of the intrinsic magnetic moment of this nucleus to that of an electron is
   (A) zero, because the nucleus has no intrinsic magnetic moment (B) greater than 1, because the nucleus contains many protons (C) greater than 1, because the nucleus is so much larger in diameter than the electrons (D) less than 1, because of the strong interactions among nucleons in a nucleus (E) less than 1, because the nucleus has a mass much larger than that of the electron
10. The ground state configuration of a neutral sodium atom (Z = 11) is
    (A) $1s^2 2s^2 2p^5 3s^2$ (B) $1s^2 2s^3 2p^6$ (C) $ls^2 2s^2 2p^6 3s$ (D) $1s^2 2s^2 2p^6 3p$ (E) $ls^2 2s^2 2p^5$
11. The ground state of the helium atom is a spin
    (A) singlet (B) doublet (C) triplet (D) quartet (E) quintuplet
12. If ν is frequency and h a is Planck's constant, the ground state energy of a one-dimensional quantum mechanical harmonic oscillator is
    (A) 0 (B) $\frac{1}{3}h\nu$ (C) $\frac{1}{2}h\nu$ (D) $h\nu$ (E) $\frac{3}{2}h\nu$
13. A particle of mass m is confined to an infinitely deep square-well potential: $V(x) = \infty, x \leq 0, x \geq a$; $V(x) = 0,\ 0 < x < a$. The normalized eigenfunctions, labeled by the quantum number n, are $\psi_n = \sqrt{\frac{2}{a}}\sin(\frac{n\pi x}{a})$. For any state n, the expectation value of the momentum of the particle is
    (A) 0 (B) $\frac{\hbar n\pi}{a}$ (C) $\frac{2\hbar n\pi}{a}$ (D) $\frac{\hbar n\pi}{a}(\cos n\pi - 1)$ (E) $\frac{-i\hbar n\pi}{a}(\cos n\pi - 1)$

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14. Following from 13. The eigenfunctions satisfy the condition $\int_0^a \psi_n^*(x)\psi_\ell(x)dx = \delta_{n\ell}$, $\delta_{n\ell} = 1$ if $n = \ell$, otherwise $\delta_{n\ell} = 0$. This is a statement that the eigenfunctions are

(A) solutions to the Schrodinger equation (B) orthonormal (C) bounded
(D) linearly dependent (E) symmetric

15. Following from 13. A measurement of energy E will always satisfy which of the following relationships?

(A) $E \leq \frac{\pi^2\hbar^2}{8ma^2}$ (B) $E \geq \frac{\pi^2\hbar^2}{2ma^2}$ (C) $E = \frac{\pi^2\hbar^2}{8ma^2}$ (D) $E = \frac{n^2\pi^2\hbar^2}{8ma^2}$ (E) $E = \frac{\pi^2\hbar^2}{2ma^2}$

16. Two horizontal scintillation counters are located near the Earth's surface. One is 3.0 meters directly above the other. Of the following, which is the largest scintillator resolving time that can be used to distinguish downward-going relativistic muons from upward-going relativistic muons using the relative time of the scintillator signals?
(A) 1 picosecond (B) 1 nanosecond (C) 1 microsecond
(D) 1 millisecond (E) 1 second

17. The state of a quantum mechanical system is described by a wave function ψ. Consider two physical observables that have discrete eigenvalues: observable A with eigenvalues $\{\alpha\}$, and observable B with eigenvalues $\{\beta\}$. Under what circumstamoes can all wave functions be expanded in a set of basis states, each of which is a simultaneous eigenfunction of both A and B?
(A) Only if the values $\{\alpha\}$ and $\{\beta\}$ are nondegenerate state (B) Only if A and B commute
(C) Only if A commutes with the Hamiltonian of the system
(D) Only if B commutes with the Hamiltonian of the system (E) Under all circumstances

18. In a ^{3}S state of the helium atom, the possible values of the total electronic angular momentum quantum number are

(A) 0 only (B) 1 only (C) 0 and 1 only (D) 0, $\frac{1}{2}$, and 1 (E) 0, 1, and 2

19. Solid argon is held together by which of the following bonding mechanisms?
(A) Ionic bond only (B) Covalent bond only (C) Partly covalent and partly ionic bond
(D) Metallic bond (E) van der Waals bond

20. The ratio of the energies of the K characteristic x-rays of carbon (Z=6) to those of magnesian (Z=12) Is most nearly

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 1 (D) 2 (E) 4