國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：近代物理【物理系碩士班】　　題號：423001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（選擇題）　　共3頁第1頁

單選題［共十一題］

＊1~9題每題10分，10~11題每題5分，答錯不倒扣。

1. [10%] Can a photon transfer all of its energy to a free electron?
   A. Yes
   B. No
   C. It depends on the photon's energy
   D. It depends on photon's polarization

2. [10%] A photon of initial energy 0.1 MeV undergoes Compton scattering at an angle of 60°. What is the energy of the scattered photon? (The rest energy of electron is $m_e c^2 = 0.511$ MeV.)
   A. 8.361×10^4 eV
   B. 8.55×10^4 eV
   C. 8.741×10^4 eV
   D. 9.111×10^4 eV

3. [10%] It's known that energy levels of hydrogen follows $E_n = -13.6/n^2$ eV with $n = 1, 2, 3, \ldots$ Consider a process that an electron in hydrogen makes a transition from the $n = 2$ state to the $n = 1$ state without emitting a photon. Instead, the excess energy is transferred to an outer electron in the $n = 4$ state, which is ejected by the atom. What is the kinetic energy of the ejected electron?
   A. 2.55 eV
   B. 9.35 eV
   C. 10.2 eV
   D. 11.05 eV

4. [10%] Estimate the order of the kinetic energy of an electron confined within a nucleus of size 1.0×10^{-14} m by using the uncertainty principle.
   A. 10 eV
   B. 10 keV
   C. 10 MeV
   D. 1 GeV

5. [10%] A light source of wavelength illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 1.0 eV. A second light source with half the wavelength of the first ejects photoelectrons with a maximum kinetic energy of 4.0 eV. What is the work function of the metal?
   A. 0.5 eV
   B. 2.0 eV
   C. 3.5 eV
   D. 4.0 eV

6. [10%] The radial part of a wave function for an atom is given by $\psi(r) = Ar^2 e^{-\frac{r}{2a_0}}$ where A is the normalization constant and a_0 is a positive number. Calculate the expectation value of r for this state.
   A. $2a_0$
   B. $3a_0$
   C. $4a_0$
   D. $5a_0$

7. [10%] What is the ground-state energy of 5 non-interacting bosons (of mass m) in a one-dimensional box of length L?
   A. 0
   B. $\frac{\pi^2\hbar^2}{2mL^2}$
   C. $\frac{5\pi^2\hbar^2}{2mL^2}$
   D. $\frac{55\pi^2\hbar^2}{2mL^2}$

8. [10%] For $l = 2$, what is the minimum value of $(L_x)^2+(L_y)^2$, where L_x and L_y are x and y components of angular momentum?
   A. 0
   B. $\hbar^2$
   C. $2\hbar^2$
   D. $6\hbar^2$

9. [10%] Which of the following atoms would you expect to have no ground state split by the spin-orbit interaction?
   A. Na
   B. Al
   C. Si
   D. Cu

10. [5%] Which line in Figure 1 should be the Fermi distribution?
    A. A
    B. B
    C. C

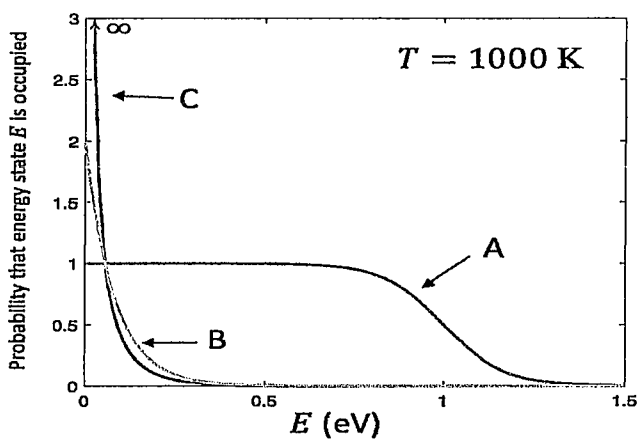

Figure 1

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11. [5%] The band structure for an imaginary semiconductor is shown in Figure 2, where E_F is the Fermi energy. What is the minimal photon energy to directly excite an electron from the valence band to the conduction band?

A. 0.7 eV
B. 0.8 eV
C. 1.2 eV
D. 1.5 eV

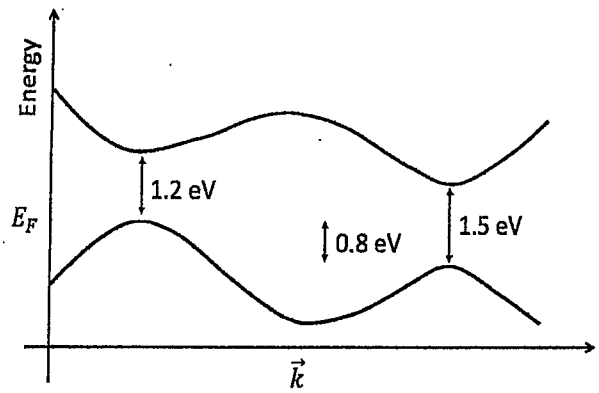

Figure 2

國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：普通物理【物理系碩士班選考】　　題號：423002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）(問答申論題)　　共1頁第1頁

Useful physical constant: permittivity constant (ε_0: 8.85×10^{-12} $C^2/N \cdot m^2$); electron charge (e: 1.6×10^{-19} C)

1 [15%]. A hot-air balloon of diameter 10 m rises vertically at a constant speed of 12 m/s. A passenger accidently drops his camera from the railing of the basket when it is 18 m above the ground. If the balloon continues to rise at the same speed, how high is the railing when the camera hits the ground?

2 [20%]. Please calculate the rotational inertia for the following uniform objects of inertia M and radius R about axes through their center of mass

(a) **[10%]** thin-walled sphere

(b) **[10%]** solid sphere.

3 [15%]. A uniform disk of mass m and radius R lies in a vertical plane and is pivoted about a point a distance l_{cm} from its center of mass. When given a small rotational displacement about the pivot, the disk undergoes simple harmonic motion. Determine the period of this motion.

4 [15%]. An infinitely long nonconducting solid cylinder of radius R has a nonuniform but cylindrically symmetrical charge distribution. The volume charge density is given by $\rho(r) = c/r$, where c is a positive constant having units C/m^2 and r is the radial distance from the long central axis of the cylinder.

(a) **[5%]** What is the charge in a section of the cylinder of length l?

(b) **[5%]** Write an expression for the dlectric field magnitude for $r < R$.

(c) **[5%]** Write an expression for the dlectric field magnitude for $r > R$.

5[20%]. A certain wire has a circular cross section of radius R and carries a current I. Suppose that the charge carriers all move along the cylindrical surface of the wire, not through its cross-sectional area.

(a) **[10%]** Derive an expression for the magnetic field magnitude B(r) as a function of distance r from the center of the wire; check that your expression makes sense for r < R and for r > R.

(b) **[10%]** Make a graph showing the magnitude of the magnetic field in and around the wire as a function of the radial distance r from the center. Mark the wire radius R on your graph.

6 [15%]. Two parallel-plate capacitors are identical except that capacitor 1 has vacuum between the plates and capacitor 2 has a dielectric slab of dielectric constant κ filling the space between the plates. Each capacitor is isolated (that is, not connected to a battery), and they store equal quantities of charge. Compare the two based on

(a) **[3%]** capacitance,

(b) **[3%]** potential difference between the plates,

(c) **[3%]** energy stored,

(d) **[3%]** electric field magnitude between the plates, and

(e) **[3%]** energy density.

試題隨卷繳回