國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：近代物理【光電所碩士班選考】　　題號：435003

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（選擇題）　　

I. For each question find one correct answer from five possible choices:

1. (2 points) The phenomenon of the emission, or ejection, of electrons from the surface of a metal in response to incident light is known as
   (a) photon-electron collision effect, (b) photon-induced-current effect, (c) photo-electric effect, (d) light-induced-conducting effect, (e) light-electric-coupling effect.

2. (3 points) The energy that can be obtained from complete annihilation (完全湮滅) of 1 g of mass is
   (a) 0, (b) 0.001 J, (c) 10^{10} J, (d) 3×10^{13} J, (e) 9×10^{13} J.

3. (3 points) If the energy produced from complete annihilation of 1 g of mass (c.f., question 1) is completely convert to photon, the wavelength of the light can be
   (a) 2.2×10^{-39} m, (b) 2.2×10^{-20} m, (c) 2.2×10^{-15} m,
   (d) 2.2×10^{-12} m, (e) 2.2×10^{-9} m.

4. (2 points) In his scattering experiment, Rutherford and his colleagues used a beam of α-particle that composes of
   (a) one electron, (b) one electron and one proton,
   (c) one proton and one neutron, (d) two protons and one neutron,
   (e) two protons and two neutrons.

5. (5 points) If a rod of length L_0 travels, in the sky, with a speed $u = 0.8c$ along its length, its length as observed by a man on the ground, will be
   (a) $0.4L_0$, (b) $0.6L_0$, (c) $0.8L_0$, (d) L_0, (e) $1.2L_0$.

6. (5 points) At 0 K, the Fermi energy of silver (Ag) is 5.54 eV. The Fermi temperature of silver is
   (a) 65000 K, (b) 5000 °C, (c) 0 K, (d) 100 °C, (e) 0 °C.

7. (5 points) The mean life-time of muons is 2.4×10^{-6} s when they decay at rest. When a beam of muons travels with a speed of $u = 0.8c$, their mean life-time as observed in the laboratory is found to be
   (a) 2.0×10^{-6} s, (b) 2.5×10^{-6} s, (c) 3.0×10^{-6} s, (d) 4.0×10^{-6} s, (e) 5.0×10^{-6} s.

8. (5 points) For hydrogen atom at very high energy level, i.e., the principle quantum number n is very large, the gap between the neighboring energy levels is proportional to
   (a) n^2, (b) n, (c) $\frac{1}{n}$, (d) $\frac{1}{n^2}$, (e) $\frac{1}{n^3}$.

9. (5 points) The ground state electron configuration of sodium (Na: Z = 11) is
   (a) 1s, (b) $1s^2 2s^2 2p^6 3s$, (c) $1s^2 2s^2 2p^6$, (d) $1s^2 2s^2 2p^6 3s^2$,
   (e) $1s^2 2s^2 2p^6 3s^2 3p$.

10. (5 points) Point out which one of following transitions is forbidden.
    (a) $2p \rightarrow 1s$, (b) $3s \rightarrow 2p$, (c) $2s \rightarrow 1s$, (d) $3p \rightarrow 1s$, (e) $3p \rightarrow 2s$.

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II When potassium, which has a work function $\phi = 2.0$ eV, is exposed to a beam of light of wavelength $\lambda = 400$ nm, the electrons are found to emit from the metal.

11. (5 points) The photons in the light beam have an energy
(a) 3.1 eV, (b) 4.0 eV, (c) 5.2 eV, (d) 6 eV, (e) 8 eV;

12. (5 points) The velocity of the electrons emitted can be
(a)400 nm/s, (b) 800 nm/s, (c) 5.5×10^5 m/s, (d) 6.22×10^5 m/s, (e) 8.0×10^5 m/s;

13. (10 points) The electrons have a wavelength
(a) 400 nm, (b) 800 nm, (c) 1.17 nm, (d) 0.5 nm, (e) 0.25 nm.

III. For the velocity distribution of gas molecules of mass m at temperature T is

$$N(u)du = 4\pi N\left(\frac{m}{2\pi kT}\right)^{3/2} \exp\left(-\frac{mu^2}{2kT}\right)u^2 du . \qquad (1)$$

Based on the distribution function solve following problems (14 and 15).

14. (10 points) The average speed of gas molecule $\langle u \rangle$ is

(a) $\left(\frac{kT}{\pi m}\right)^{1/2}$, (b) $\left(\frac{8kT}{3\pi m}\right)^{1/2}$, (c) $\left(\frac{8kT}{\pi m}\right)^{1/2}$, (d) $\left(\frac{4kT}{\pi m}\right)^{1/2}$, (e) $\left(\frac{2kT}{\pi m}\right)^{1/2}$,

15. (10 points) The equation (1) is known as Maxwellian distribution, in which the most probable speed of the gas molecules is $u_p = (2kT/m)^{1/2}$. For Maxwellian distribution, the root mean square of speed is written as $\langle u^2 \rangle^{1/2}$. So the relation of the three speeds is

(a) $\langle u^2 \rangle < u_p^{\,2} < \langle u \rangle^2$, (b) $\langle u^2 \rangle = u_p^{\,2} < \langle u \rangle^2$,

(c) $u_p^{\,2} < \langle u^2 \rangle < \langle u \rangle^2$, (d) $u_p^{\,2} < \langle u^2 \rangle = \langle u \rangle^2$,

(e) $u_p^{\,2} < \langle u \rangle^2 < \langle u^2 \rangle$.

IV · A particle at ground state is described by the wave function

$$\psi(p) = \frac{\sqrt{8}}{\pi}\left(\frac{\hbar}{a_0}\right)^{\frac{5}{2}} \Bigg/ \left[p^2 + \left(\frac{\hbar}{a_0}\right)^2\right]^2$$, where $\hbar$ is Plank constant, p is the momentum of the particle and a_0 is a constant.

16. (5 points) The momentum distribution $f(\vec{p})d\vec{p}$ can be given by

(a) $-\frac{\sqrt{8}}{\pi}\frac{\left(\frac{\hbar}{a_0}\right)^{\frac{5}{2}}}{\left[p^2 + \left(\frac{\hbar}{a_0}\right)^2\right]^2}dp$, (b) $\frac{\sqrt{8}}{\pi}\frac{\left(\frac{\hbar}{a_0}\right)^{\frac{5}{2}}}{\left[p^2 + \left(\frac{\hbar}{a_0}\right)^2\right]^2}dp$

(c) $\frac{8}{\pi}\frac{\left(\frac{\hbar}{a_0}\right)^5}{\left[p^2+\left(\frac{\hbar}{a_0}\right)^2\right]^4}pdp$, (d) $\frac{8}{\pi^2}\frac{\left(\frac{\hbar}{a_0}\right)^5}{\left[p^2+\left(\frac{\hbar}{a_0}\right)^2\right]^4}(4\pi)p^2dp$,

(e) $\frac{\left(\frac{\hbar}{a_0}\right)^5}{\left[p^2+\left(\frac{\hbar}{a_0}\right)^2\right]^4}4\pi p^2dp$.

17. (5 points) The most probable magnitude of the momentum of the particle is

(a) $\frac{\hbar}{a_0}$, (b) $\frac{\hbar}{\sqrt{3}\,a_0}$, (c) $\frac{\hbar}{\sqrt{2}\,a_0}$, (d) $\frac{\hbar}{3a_0}$, (e) $\frac{\hbar}{2a_0}$.

18. (10 points) The expectation value of momentum $\langle p\rangle$ is

(a) $\frac{8\hbar}{\pi\ a_0}$, (b) $\frac{4\hbar}{\pi\ a_0}$, (c) $\frac{8\hbar}{3\pi\ a_0}$, (d) $\frac{2\hbar}{\pi\ a_0}$, (e) $\frac{8\hbar}{5\pi\ a_0}$.

Constant and special functions

Plank's constant: $h = 6.63 \times 10^{-34}$ J·s
Mass of electron: $m_e = 9.109 \times 10^{-31}$ kg
$1J = 6.2415 \times 10^{18}$ eV
Boltzmann constant: $k = 1.38 \times 10^{-23}$ J K^{-1}
Avogaderlor constant: $N_a = 6.022 \times 10^{23}$ mol^{-1}
Ground energy of hydrogen : -13.6 eV
Charge of electron: 1.602×10^{-19} C
Speed of light: $c = 3.0 \times 10^8$ m s^{-1}

Values of the integral $I_n = \int_0^\infty x^n e^{-ax^2}dx$

n	I_n
0	$\frac{1}{2}\pi^{1/2}a^{-1/2}$
1	$\frac{1}{2}a^{-1}$
2	$\frac{1}{4}\pi^{1/2}a^{-3/2}$
3	$\frac{1}{2}a^{-2}$
4	$\frac{3}{8}\pi^{1/2}a^{-5/2}$