國立中央大學 113 學年度碩士班考試入學試題

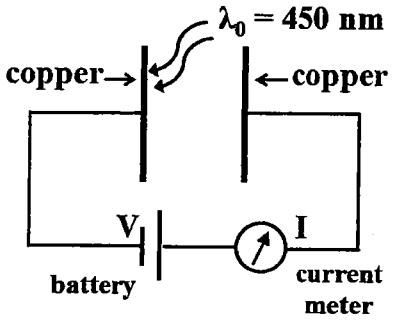
所別： 光電類

科目： 近代物理

＊本科考試可使用計算器，廠牌、功能不拘

Choose the correct single answer (total: 100 %, each: 5%):

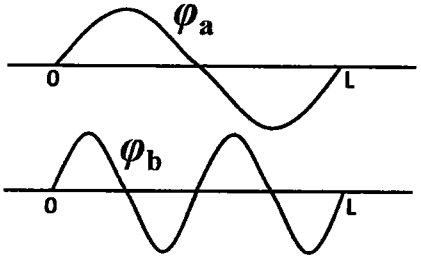
(1) Two copper plates are connected to a battery and a current meter, as depicted in the figure. When the battery is set to be 2 V and a blue light (wavelength: 465 nm) is shined on one of the plates, the current meter reads 3 μA. The current meter reads zero when the battery is set to be -3 V (with the same blue light incidence). What can be the possible voltage of the battery when the incident wavelength is decreased to be 400 nm?



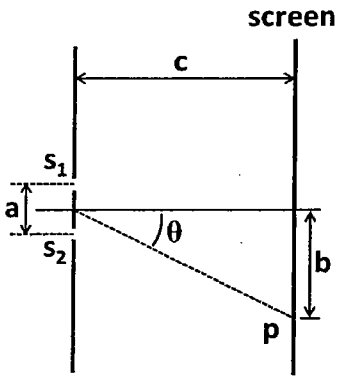
(A) -2 V (B) 3 V (C) 0 V (D) 1 V (E) -4 V

(2) What is the total mass of the electrons contained in -1 C of charge?
(A) 5.6×10^{-10} kg (B) 5.6×10^{-11} kg (C) 5.6×10^{-12} kg (D) 5.6×10^{-13} kg (E) 5.6×10^{-14} kg

(3) A particle is strictly confined in a region of length L, but moving freely in the region. Two possible wavefunctions, φ_a and φ_b, of the particle are those shown in the figure. When the particle is in the state corresponding to the wavefuction φ_a, its total energy is 1 eV. What is its total energy in the state corresponding to φ_b? (A) 1 eV
(B) 2 eV (C) 4 eV (D) 8 eV (E)None of the above



(4) The spherical waves of wavelength λ emitted from a single point source are passing through two small holes, S_1 and S_2, which are separated by the distance of **a**, as shown in the figure. If **c** >> **a**, what is the approximated condition for destructive interference at a point P on the screen? (A) **b**sinθ = 1.5λ (B) **a**tanθ = 1.5λ (C) **c**sinθ = λ
(D) **b**tanθ = λ (E) **a**sinθ = λ



(5) A particle is trapped in a potential well with the depth of E_0. If the wavefunction of the particle is $\varphi(x,t) = A\sin(\omega t+kx) + i\,A\cos(\omega t+kx)$, where A, ω and k are constants and ***i*** is the unit imaginary number, what is the probability, per unit length of the x axis, of finding the particle near the coordinate x at time t?
(A) A^2 (B) $E_0\cos(\omega t+kx)$ (C) $A\sin(\omega t+kx)$ (D) A (E) None of the above

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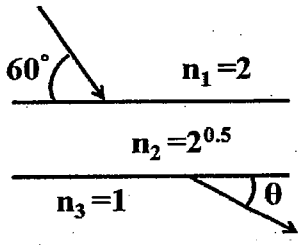
(6) A light beam is traveling in a structure with three layers of different refractive indices: $n_1=2$, $n_2=2^{0.5}$, $n_3=1$. If the beam impinges at the interface between n_1 and n_2 with the incident angle of 60°, as shown in the figure, what is θ when the light beam enters the layer with $n_3=1$? (A) 30° (B) 45° (C) 90° (D) 0° (E) 60°



(7) What is the 3rd energy level for an electron in a quantum well of width 1 nm with infinite walls? (A) 3.393 eV (B) 0.377 eV (C) 6.032 eV(D) 1.508 eV (E) None of the above.

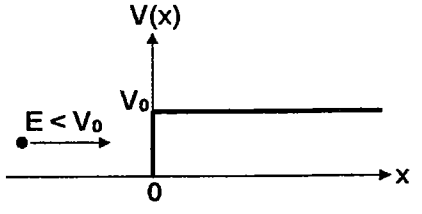
(8) Light passes from air into a liquid and is deviated 19° when the angle of incidence is 52°. What is the index of refraction of the liquid? (A) 1.33 eV (B) 1.55 eV (C) 1.74 eV(D) 1.45 (E) 1.28

(9) A laser beam of wavelength λ shined on a spectrometer with the grating spacing a is split into two beams of wavelengths λ_1 and λ_2 due to the 2nd order diffraction. If λ_2 is slightly longer than λ_1 and θ is the diffraction angle for λ_1, what is the difference in difraction angles of the two beams? (A) $\frac{(\lambda_2-\lambda_1)\sin\theta}{2a}$ (B) $\frac{\lambda_1-\lambda_2}{a\sin\theta}$ (C) $\frac{2(\lambda_2-\lambda_1)}{a\tan\theta}$ (D) $\frac{2(\lambda_1-\lambda_2)}{a\sin\theta}$ (E)None of the above

(10) If the wavelength of a moving electron is 450 nm, what is the velocity of that electron? (A) 1.32×10^5 cm/s (B) 2.32×10^5 cm/s (C) 3.62×10^5 cm/s (D) 2.43×10^5 cm/s (E) None of the above

(11) In the Bohr hydrogen model, an electron moves around the nucleus with different orbits. If the electron is of the energy, E, and moves in the 3rd lowest orbital, what is the period for one revolution? (A) $3\pi\hbar/|E|$ (B) $\pi\hbar/|E|$ (C) $\pi\hbar/3|E|$ (D) $6\pi\hbar/|E|$ (E) None of the above.

(12) Consider a particle traveling in the potential step (V_0) shown in the figure. If the particle is of the energy $E < V_0$, what can be the correct type of wavefunction for the particle at $x > 0$? (A) $Ae^{ikx} + Be^{-ikx}$ (B) Ae^{ikx} (C) Ae^{-kx} (D) Ae^{-ikx} (E) $Ae^{ikx} + Be^{-kx}$



(13) When a bullet of the mass m, is fired from a gun, the speed and the location of the bullet are to be measured simultaneously. If the speed is measured with an uncertainty of Δv, what is the fundamental accuracy of the location, Δx, in the measurement? (A) $h/4\pi m\Delta v$ (B) $h/\Delta v$ (C) $h/\pi m\Delta v$ (D) $h/2\Delta v$ (E) $h/4\Delta v$. (h is Planck's constant)

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(14) When a fish looks up at the surface of a perfectly smooth lake, the surface appears dark except inside a circular area directly above it. What is the angle that this illuminated region subtends? (hint: the index of refraction of water is 1.333) (A) 57.2° (B) 97.2° (C) 67.2° (D) 77.2° (E) 87.2°

(15) Two mirrors, each 1.6 m long, are facing each other. The distance between the mirrors is 20 cm. A light ray is incident on one end of one of the mirrors at angle of incidence of 30°. How many times (counting the first one) is the ray reflected before it reaches the other end? (A) 10 (B) 11 (C) 12 (D) 13 (E) 14

(16) A marble with speed 20 cm/s rolls off the edge of a table 80 cm high. How far, horizontally, from the table edge does the marble strike the floor ? (A) 6 cm (B) 7 cm (C) 8 cm (D) 9 cm (E) 10 cm

(17) An electron is trapped in an infinitely deep potential well with the width of 5 nm. When the electron is transferred from energy level E_2 to E_1, a photon of the wavelength 800 nm is emitted. If the width of the infinite well is increased to 10 nm, and the trapped electron is still transferred from E_2 to E_1, what can be the emitted photon wavelength? (A) 200 nm (B) 400 nm (C) 600 nm (D) 800 nm (E) 1000 nm

(18) The charge of a parallel-plate capacitor is varying as $q = q_0 \sin(2\pi ft)$. The plates are very large and close together (area: A; separation: d). Neglecting edge effects, what is the displacement current through the capacitor? (A) $2\pi fq_0 \cos(2\pi ft)$ (B) $\pi fq_0 \cos(2\pi ft)$ (C) $4\pi fq_0 \cos(2\pi ft)$ (D) $2\pi fq_0 \cos(\pi ft)$ (E) $2\pi fq_0 \cos(4\pi ft)$

(19) The magnetic field (B) of an electromagnetic wave obeys the following relation in a certain region: $B = 10^{-12} \sin(5\times10^6 t)$ where all quantities are in SI units. How large an electro-motive force would the field induce in a 300-turn coil of 20-cm^2 area oriented perpendicular to the filed? (A) $-7\times10^{-6} \cos(5\times10^6 t)$ V (B) $-3\times10^{-6} \cos(8\times10^6 t)$ V (C) $-3\times10^{-6} \cos(5\times10^8 t)$ V (D) $-3\times10^{-6} \cos(5\times10^6 t)$ V (E) $-3\times10^{-4} \cos(5\times10^6 t)$ V

(20) Two point charges are 3 m apart, and their combined charge is 20 μC. If one repels the other with a force of 0.075 N, what are the two charges? (A) 10 and 10 μC (B) 5 and 15 μC (C) 7 and 13 μC (D) 9 and 11 μC (E) 4 and 16 μC

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