台灣聯合大學系統 105 學年度碩士班招生考試試題

類組:電機類 科目:近代物理(300F)

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※選擇題請在答案卡內作答,非選擇題請在答案卷內作答

單選(40%),每題5分

- 1. An alien spaceship streaks past the football stadium along the direction of play at 0.6c (as measured by the players on the field). A football field is 120 yards long by 55 yards wide. What is the length of the football field according to the alien?
 - (A) 120 yards
 - (B) 150 yards
 - (C) 96 yards
 - (D) 189.7 yards
 - (E) 75.9 yards.
- 2. A spaceship whose rest length is 300.0 m has a speed of 0.80c with respect to a certain reference frame. A micrometeorite, also with a speed of 0.80c in this frame, passes the spaceship on an antiparallel track. How long does it take this object to pass the spaceship?
 - (A)1.110 μs
 - (B) $1.080 \mu s$
 - (C) $1.055 \mu s$
 - (D)1.025µs
 - (E) 1.010µs
- 3. Two identical objects, each of rest mass m₀, moving with equal but opposite velocities of 0.60c in the laboratory reference frame, collide and stick together. The resulting particle has a rest mass M₀. Is M₀ equal to
 - (A) $1.5 \, \text{m}_0$
 - (B) $2.0 m_0$
 - $(C) 2.5m_0$
 - (D) $3.0m_0$
 - $(E) 3.5m_0.$
- 4. Which of the following phenomena most clearly demonstrates the wave nature of electrons? (A)The photoelectric effect.
 - (B)Blackbody radiation
 - (C)The Compton effect.
 - (D)Diffraction of electrons by crystals.
 - (E)Non of these answers.
- 5. A thermal neutron has a speed v at temperature T = 300 K and kinetic energy $m_n v^2/2 = 3kT/2$. By Heisenberg's Uncertainty principle, what is the estimated kinetic energy (in MeV) of a nucleon bound within a nucleus of radius 10^{-15} m?
 - (A) 960.48.
 - (B) 763.
 - (C) 20.48.
 - (D) 197.48.
 - (E) 177.

注:背面有試題

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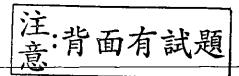
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- 6. A hydrogen atom is in an excited state with the electron in a p-shell. Which of the following sets of quantum numbers n, ℓ, m is not consistent with this statement?
 - (A) n, ℓ , m = 1, 1, 0.
 - (B) n, ℓ , m = 2, 1, 1.
 - (C) n, ℓ , m = 2, 1, 0.
 - (D) n, ℓ , m = 2, 1, -1.
 - (E) n, ℓ , m = 3, 1, 0.
- 7. Consider the electrons in a 1D metal and describe them as free particles. Let $E(k) = p^2/2m$ be the energy of an electron with momentum p. Then, the corresponding phase velocity of the electron wave is given by
 - (A) p/m
 - (B) p/(2m)
 - (C) 2p/m
 - (D) $2^{1/2}$ p/m
 - (E) None of the above
- 8. Consider two free electrons in 1D having the <u>same wave vector k</u> but <u>opposite spins</u>, e.g., one with the z-spin being '+' (up) and the other with the z-spin being '-' (down). Let their position coordinates be x and x', and the z-spin variables be s and s', respectively (We use, for example, the notation |s=+> to denote the up-spin state of the 1st electron, and so on.) Which of the following expressions gives the correct, normalized wave function for the two electrons?
 - (A) $e^{ikx}e^{ikx'}|_{S}=+>|_{S}'=->$
 - (B) $e^{ikx}e^{ikx'}(|s=+>|s'=->+|s=->|s'=+>)/2^{1/2}$
 - (C) $e^{ikx}e^{ikx}$ ($|s=+\rangle|s'=+\rangle + |s=-\rangle|s'=-\rangle)/2^{1/2}$
 - (D) $e^{ikx}e^{ikx'}$ ($|s=+\rangle|s'=-\rangle |s=-\rangle|s'=+\rangle)/2^{1/2}$
 - (E) None of the above

複選(40%),每題5分

- 9. Which are the following statements correct?
 - (A) The maximum kinetic energy of the recoil electron in Compton scattering is given by $\frac{hf}{\frac{mc^2}{2hf}+1}$, where f is the frequency of the incident photon, h the Plank constant, c speed of the light and m rest mass of an electron.
 - (B) The black body radiation curve for different temperatures peaks at a wavelength inversely proportional to the temperature.
 - (C) The photon is massless so that the gravitational force will not affect its frequency as it leaves a start.
 - (D) The maximum kinetic energy of the emitted photoelectron depends on the frequency of the incident light.
 - (E) x-rays were found to be unaffected by electric and magnetic fields, to pass readily through opaque materials and to cause phosphorescent to glow.



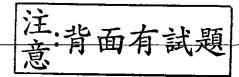
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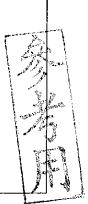
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- 10. X-rays having energy of 250 keV undergo Compton scattering from a target. The scattered rays are detected at 41° relative to the incident rays. Which of the following statements are true: (hint $\sin 41^{\circ} = 0.656$, $\cos 41^{\circ} = 0.7547$)
 - (A) The wavelength of incident X-ray is 4.96×10^{-3} nm.
 - (B) The Compton wavelength shift at this angle is 5.15×10^{-4} nm.
 - (C) The wavelength of scattered X-ray is 5.95×10⁻³ nm.
 - (D) The energy of the scattered X-ray is 223.2 keV.
 - (E) The kinectic energy of the recoiling electron is 26.8 keV.
- 11. Which are the following statements correct?
 - (A) At every instant the ratio of the magnitude of the electric field to the magnitude of the magnetic field in an EM wave equals to the speed of light.
 - (B) The instant energy density associated with the magnetic field of an EM wave equals to the instant density associated with the electric field.
 - (C) The intensity of an EM wave is proportional to the cube of the amplitude of magnetic field.
 - (D) Classical wave equation is invariant under Galileo transformation.
 - (E) The intensity of an EM wave equals the average energy density multiplied by the speed of light.
- 12. Ytterbium (Yb) has a work function $\phi = 2.6$ eV. Which of the following statements are true:
 - (A) The lowest frequency f that can liberate an electron from Yb is 6.29×10^{13} Hz.
 - (B) The longest wavelength λ that can liberate an electron from Yb is 476.9 nm.
 - (C) Suppose light with wavelength λ =257 nm impacts some Yb. The voltage Vmax that the liberated electrons from Yb can overcome is 2.23 V.
 - (D) When an unknown light is shone on Yb, it is found that the electrons can only overcome a voltage of Vmax = 1.75 V. The wavelength of light is 708.6 nm
 - (E) None of the above
- 13. Which of the following are true for photons?
 - (A) Photons are Bose particles.
 - (B) Two photons are not allowed to occupy the same quantum state.
 - (C) They obey Bose-Einstein distribution with a finite chemical potential.
 - (D) Inside a cavity, the average photon number in a specific cavity mode (with frequency f) is approximately given by k_BT/(hf), h = Planck constant, when k_BT/h>>f.
 - (E) None of the above.
- 14. Which of the following are true for electrons?
 - (A) The same quantum state cannot be occupied by more than one electron.
 - (B) Two electrons can have the same spin state.
 - (C) At any temperature, electrons in a solid cannot be found above the Fermi level E_F.
 - (D) The existence of energy gap in a semiconductor can be proved within quantum physics.
 - (E) None of the above.





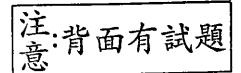
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- 15. Consider the Schrödinger Equation for the time-dependent state vector $\psi(x,t)$ of a system: $i\hbar \frac{\partial \psi(x,t)}{\partial t} = H\psi(x,t) \text{. Assume we can find a function } \varphi_E(x) \text{ such that it is an eigenstate}$ to the Hamiltonian H: $H\varphi_E(x) = E\varphi_E(x)$. Which of the following statements are true?
 - (A) A complete solution of the full Schrödinger Equation above is given by the time-independent function $\psi(x,t) = \varphi_E(x)$.
 - (B) A complete solution of the full Schrödinger Equation above is given by the timedependent function $\psi(x,t) = \varphi_E(x) \exp(i\frac{E}{\hbar}t)$.
 - (C) The full solution to the Schrödinger Equation can be written as a product $c(t)\varphi_E(x)$, where c(t) is some complex function of time.
 - (D) The function c(t) above can have any arbitrary functional form.
 - (E) If measured at some future time, the energy of the system described by $c(t)\varphi_{E}(x)$ is E.
- 16. Which of the following statements are correct?
 - (A) If electrons have been accelerated from rest through a potential difference of 54 V, then the wavelength of electrons is 1.667 nm.
 - (B) For high principle quantum number (n) for hydrogen atom, the spacing between the neighboring energy levels is proportional to $1/n^3$.
 - (C) A particle of mass m_e trapped in an infinite depth well of width L=1 nm. Consider the transition from the excited state n=2 to the ground state n=1. The wavelength of light emitted is 886.4 nm.
 - (D) The relation for total energy (E) and momentum (p) for a relativistic particle is $E^2 = c^2$ $p^2 + m^2c^4$, where m is the rest mass and c is the velocity of light. According to the relativistic relations for E and p, the product of group velocity and the phase velocity is equal to c^2 .
 - (E) If the electron wave function is Ce^{ikx} between x = 2 and 22 cm, and zero everywhere else, where C is a real constant, the probability of finding the electron between x = 0 and 4 cm is 0.1.



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計算(20%)

1. (10%)For ionic solids, the attraction electrostatic potential energy is

$$U_{\text{attatctive}} = -\alpha \cdot k \cdot \frac{e^2}{r}$$

,and the repulsive electrostatic potential energy is

$$U_{repulsive} = + \frac{B}{r^m}$$

,and the total potential energy is

$$U_{total} = U_{attatctive} = -\alpha \cdot k \cdot \frac{e^2}{r} + \frac{B}{r^m}$$

- (A) Plot the all three potential energy U per ion pair versus separation distance r, and indicate the equilibrium distance r₀ and equilibrium potential energy U₀. (5%)
- (B) Determinate the equilibrium (minimum) potential energy U_0 . (5%)
- 2. (10%) For semiconductor, use the conduction band (Ec), valence band (Ev), energy band gap (Eg) electron, hole, photon energy and energy conversation law to
- (A) Illustrate (畫圖說明) the operation principle of light-emitter diode (LED). (5%)
- (B) Illustrate (畫圖說明) the operation principle of solar cell (SC).(5%)