國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：近代物理【物理系碩士班】

—作答注意事項—

考試時間：100 分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。
- 答案卡請以 2B 鉛筆劃記，不可使用修正液（帶）塗改，未使用 2B 鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 113 學年度碩士班暨碩士在職專班招生考試試題

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 5 頁第 1 頁

一、選擇題 (共 20 題，每題 5 分，滿分 100 分)

1. What is the maximum kinetic energy (in eV) of a photoelectron when a surface, whose work function is 5.0 eV, is illuminated by photons whose wavelength is 400 nm?
   A. 3.1
   B. −1.9
   C. 1.9
   D. 0
   E. 1.2

2. How much energy is in an 89.7-MHz photon of FM radiation?
   (*Hint* : The Planck constant is $h = 6.626 \times 10^{-34}\ \mathrm{J \cdot Hz^{-1}} = 4.135 \times 10^{-15}\ \mathrm{eV \cdot Hz^{-1}}$)
   A. 2.2×10^{-33} J
   B. 5.9×10^{-27} J
   C. 7.4×10^{-42} J
   D. 9.5×10^{-26} J
   E. 3.7×10^{-25} J

3. The experimental observation(s) below that require(s) a quantum explanation for the photoelectric effect
   A. is that more photoelectrons are emitted when the light frequency increases.
   B. is that the maximum kinetic energy of the photoelectrons is related linearly to the frequency of the light.
   C. is that every metal surface has a work function, a minimum amount of energy needed to free electrons.
   D. is that the stopping potential measures the kinetic energy of the photoelectrons.
   E. are all of the above.

4. An electron is accelerated through a potential difference of 25 000 V. What is the de Broglie wavelength of the electron (in m)? (Hint : the electron mass is $m_e = 9.11 \times 10^{-31}$ kg and 1 eV = 1.602×10^{-19} J)
   A. 7.8×10^{-12}
   B. 6.8×10^{-12}
   C. 6.5×10^{-12}
   D. 5.9×10^{-12}
   E. 5.5×10^{-12}

5. Because the factor h on the right side of Heisenberg's uncertainty principle has units of joule-seconds, it suggests that the energy of a system also has uncertainty. The uncertainty in energy depends on the length of the time interval during which a system exists. $\Delta E \Delta t \geq h/4\pi$. Suppose an unstable mass is produced during a high-energy collision such that the uncertainty in its mass is $m_e/100$ ($m_e = 9.11 \times 10^{-31}$ kg). How long will this particle exist?

A. 8.1×10^{-19} s

B. 2.3×10^{-23} s

C. 1.0×10^{15} s

D. 1.2×10^{13} s

E. 6.4×10^{-20} s

6. The expectations value of a function $f(x)$ of x when the wave function depends only on x is given by $< f(x) > =$

A. $\int_{-\infty}^{+\infty} \sqrt{f(x)}\, \psi(x) dx$.

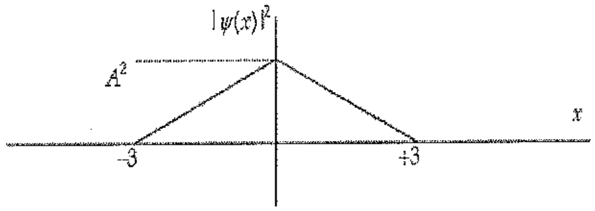
B. $\int_{-\infty}^{+\infty} f(x) \psi(x) dx$.

C. $\int_{-\infty}^{+\infty} \psi^*(x) f(x) \psi(x) dx$.

D. $\int_{-\infty}^{+\infty} f(x) \psi^*(x) dx$.

E. $\int_{-\infty}^{+\infty} \psi^*(x) \frac{f^2(x)}{2} \psi(x) dx$.

7. The graph below shows the value of the probability density $|\psi(x)|^2$ in the region -3.00 m $\leq x \leq +3.00$ m. The value of the normalization constant A is



A. $-\frac{1}{3}$.

B. $-\frac{1}{\sqrt{3}}$.

C. $+\frac{1}{\sqrt{3}}$.

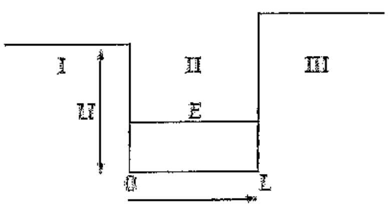
D. $+\frac{1}{3}$.

E. either $-\frac{1}{\sqrt{3}}$ or $+\frac{1}{\sqrt{3}}$.

8. What is the quantum number n of a particle of mass m confined to a one-dimensional box of length L when its energy is $2\ h^2/mL^2$?
   A. 2
   B. 4
   C. 8
   D. 1
   E. 16

9. The wave function for a particle in a box of length L is given by $\psi(x) = A\sin(\frac{n\pi x}{L})$. If the box extends from $x = 0$ to $x = L$, What is the probability of finding the particle between $x = 0.60\ L$ and $x = 0.70\ L$?
   A. 0.05
   B. 0.20
   C. 0.25
   D. 0.10
   E. The probability is not given.

10. A particle in a finite potential well has energy E, as shown below.



The wave function in region I where $x < 0$ has the form $\psi_I =$
   A. $\beta e^{\kappa x}$.
   B. $\alpha e^{-\kappa x}$.
   C. $A\sin(kx)$.
   D. $B\cos(kx)$.
   E. $A\sin(kx) + B\cos(kx)$.

11. Classically, the concept of "tunneling" is impossible. Why?
   A. The total energy of a particle is equal to the kinetic and potential energies.
   B. The velocity of the particle would be negative.
   C. The kinetic energy of the particle would be negative.
   D. The kinetic energy must be equal to the potential energy.
   E. The total energy for the particle would be negative.

12. The ground state energy of a harmonic oscillator is
    A. $E = \hbar\omega$.
    B. $E = \hbar\omega/4$
    C. $E = (2/3)\hbar\omega$.
    D. $E = 0$.
    E. $E = \hbar\omega/2$.

13. Rutherford's experiment, in which he fired alpha particles of 7.7-MeV kinetic energy at a thin gold foil, showed that nuclei were very much smaller than the size of an atom because
    A. some alpha particles passed through the foil undeflected.
    B. some alpha particles were deflected backwards.
    C. some alpha particles were captured by the gold nuclei.
    D. the alpha particles could not get closer than 10^{-10} m to the gold nuclei.
    E. the alpha particles split into deuterium nuclei when they encountered the gold nuclei.

14. An electron in a hydrogen atom makes a transition from the $n = 4$ to the $n = 3$ energy state. Determine the energy (in eV) of the emitted photon.
    A. 0.54
    B. 1.51
    C. 0.85
    D. 0.66
    E. 10.2

15. How fast is the electron moving in the first Bohr orbit?
    A. 3.3×10^6 m/s
    B. 5.5×10^{15} m/s
    C. 4.4×10^6 m/s
    D. 5.5×10^6 m/s
    E. 2.2×10^6 m/s

16. Zeke says that the magnitude of the orbital angular momentum in the hydrogen atom has the value $L = \ell\hbar$. Ruth says that the maximum magnitude of the projection of the angular momentum along the direction of a constant magnetic field vector $\vec{\mathbf{B}}$ is $\sqrt{\ell(\ell+1)}\hbar$. Which one, if either, is correct, and why?
    A. Ruth, because the maximum value of L is $\sqrt{\ell(\ell+1)}\hbar$.
    B. Ruth, because the orbital angular momentum always lines up with a magnetic field so that $\vec{\mathbf{L}}$ has its maximum value along the field.
    C. Zeke, because the maximum magnitude of $\vec{\mathbf{L}}$ is $L = \ell\hbar$.
    D. Zeke, because the orbital angular momentum always lines up with a magnetic field so that $\vec{\mathbf{L}}$ has its maximum value along the field.
    E. Neither, because they have interchanged the maximum magnitude of $\vec{\mathbf{L}}$, $\sqrt{\ell(\ell+1)}\hbar$, and $\ell\hbar$, its maximum projection along a magnetic field direction.

17. The Pauli exclusion principle states
   A. when an atom has orbitals of equal energy, the maximum number of electrons will have unpaired spins.
   B. there is an inherent uncertainty in the position and momentum of a particle.
   C. no two electrons in the same atom can have the same set of quantum numbers.
   D. when an atom has orbitals of equal energy, the maximum number of electrons will be paired spins.
   E. no two atoms can have the same set of quantum numbers.

18. As a spaceship heads directly to Earth at a velocity of $0.8c$, it sends a radio signal to Earth. When those radio waves arrive on Earth, their velocity relative to Earth is
   A. c.
   B. $0.8c$.
   C. $1.8c$.
   D. $\sqrt{c^2 + v_E^2}$, where v_E is the velocity of the Earth.
   E. $\sqrt{(0.8c)^2 + v_E^2}$, where v_E is the velocity of the Earth.

19. The speed of FM waves will be observed to be $c = 2.9979 \times 10^8$ m/s when the antenna emitting the waves is
   A. at rest relative to the receiving antenna.
   B. moving to the right of the detecting antenna at $0.5c$.
   C. moving to the left of the detecting antenna at $0.5c$.
   D. moving at 2.9979×10^8 m/s.
   E. moving as described in (a), (b) or (c) above.

20. The half-life of a muon is 2.20 μs as measured in a stationary reference frame. What is the half-life of the muon (in μs) when it is moving with a speed of $v = 0.800c$?
   A. 8.13
   B. 3.67
   C. 2.75
   D. 15.8
   E. 1.32