國立中央大學102學年度碩士班考試入學試題卷

所別：光電科學與工程學系碩士班 不分組(一般生)　科目：近代物理　共 2 頁 第 1 頁
光電科學與工程學系碩士班 不分組(在職生)
本科考試可使用計算器，廠牌、功能不拘

＊請在試卷答案卷（卡）內作答

參考用

Electron mass=9.1×10^{-31} kg
Planck's constant h=4.1357×10^{-15} eV · s
Boltzmann's constant k=1.38×10^{-23} J/K

I. Multiple choice (5% each) <單選題>

1. For a system of two electrons, each with l=1 and s=1/2, how many possible sets of quantum numbers are for the total angular momentum?
   (A) 6 (B) 10 (C) 12 (D) 16 (E) 18
2. Suppose two photons, one with energy 16 MeV and the second with energy 4 MeV, approach each other along the x axis, what is the rest energy of the system?
   (A) 0 MeV (B) 8 MeV (C) 12 MeV (D) 16 MeV (E) 20 MeV
3. When a beam of high-energy protons collides with protons at rest in the laboratory, neutral pions (π^0) are produced by the reaction p+p -> p+p+π^0. Rest energies of proton and neutral pion are 938 MeV and 135 MeV respectively, what is the threshold energy of the protons in the beam for this reaction to occur?
   (A) 280 MeV (B) 270 MeV (C) 289 MeV (D) 145 MeV (E) 110 MeV
4. Compton used photons of wavelength 0.071 nm, what is the energy of the photons scattered at θ=120°? (A) 1.63×10^4 eV (B) 1.66×10^4 eV (C) 1.74×10^4 eV (D) 1.77×10^4 eV (E) 1.90×10^4 eV
5. If a beam of oxygen atoms (Z=8) is used in a Stern-Gerlach experiment, how many lines would be expected on the detector plate?
   (A) 1 (B) 2 (C) 3 (D) 5 (E) 7
6. Which following wavelength does not belong to a hydrogen spectral series?
   (A) 122 nm (B) 487 nm (C) 703 nm (D) 821 nm (E) 1005 nm
7. If the scattering angle for electrons from a crystal with spacing D=0.21 nm is 35.7°, what is the energy of the electrons?
   (A) 70 eV (B) 80 eV (C) 90 eV (D) 100 eV (E) 110 eV
8. What is the total kinetic energy of translation of 1 mole of N_2 atoms at T=273 K
   (A) 1133 J (B) 3400 J (C) 5667 J (D) 6800 J (E) 7933 J
9. In a Franck-Hertz experiment, if electrons of energy up to 13.0 eV can be produced in the tube filled with hydrogen atoms, how many hydrogen lines can be emitted from the tube?
   (A) 3 (B) 4 (C) 5 (D) 6 (E) 7
10. If a proton is in an infinite square well potential with L=1 fm, what is the first excited state energy in MeV?
    (A) 205 (B) 410 (C) 820 (D) 1230 (E) 1640

注意：背面有試題

參考用

II.

11. (a) Prove that the pair production can't occur with an isolated photon. (5%)
(b) The pair production process usually occurs near an atomic nucleus. Is it possible for the process to occur with the help of an electron instead of a nucleus? Please explain and verify your answer. (4%)

12. (a) Derive the Heisenberg uncertainty relation between the position and momentum from the observation of an experiment showing the diffraction of a particle passing through a slit (Hint: using the knowledge you learned about the diffraction pattern of a light passing through a slit). (5%)
(b) Using the uncertainty principle derived in (a) to explain why photons can not escape from a black hole. (3%)
(c) Find the minimum energy of a harmonic oscillator of oscillation frequency ω. (4%)

13. (a) Explain why the classical physics in modeling the planetary motion fails in the analysis of the atomic structure? Give at least two observations from the atomic system to support your explanation. (4%)
(b) How did Bohr postulate to correct the failure of the classical theory to build his famous model of the hydrogen atom? (4%)
(c) Based on Bohr's model, prove that the possible energies of an electron in a hydrogen atom are quantized. (3%)
(d) Design an experiment to manifest Bohr's theory of atomic energy levels. Please detail the experimental setup and the based working principle. (5%)

14. (a) What are the internal, normal, and anomalous Zeeman effects? (4%)
(b) Write down the ground-state electron configuration of $_{11}$Na. Draw the energy-level diagram of a Na atom up to its first excited state under the internal and anomalous Zeeman effects (label each energy level with spectroscopic notation ("term symbol")). (5%)
(c) The characteristic lines (D lines) from the first excited state of Na are ~5890 and ~5896 Å. Please deduce the internal magnetic field of Na. (4%)

注意：背面有試題