

國立清華大學 101 學年度碩士班考試入學試題

系所班組別：核子工程與科學研究所 甲組（工程組）

工程與系統科學系碩士班 丙組

先進光學科技碩士學位學程 工程與系統科學組

考試科目（代碼）：近代物理（2703）（9802）

共 2 頁，第 1 頁 \*請在【答案卷、卡】作答

Useful constants:  $c = 3.00 \times 10^8$  m/s,  $k_B = 1.38 \times 10^{-23}$  J/K,  $h = 6.63 \times 10^{-34}$  J·s,  
 $e = 1.60 \times 10^{-19}$  C,  $m_e = 9.11 \times 10^{-31}$  Kg,  $\mu_B = 9.274 \times 10^{-24}$  J/T,  $R = 1.097 \times 10^7$  m<sup>-1</sup>,  
Avogadro constant  $N_A = 6.022 \times 10^{23}$  mol<sup>-1</sup>, mass of neutron:  $1.6749 \times 10^{-27}$  kg

- (15%) The total energy of a proton is three times its rest energy, what is the speed of this proton (in m/s)? (show the derivations)
- (13%) (a) Write down the Compton scattering formula.  
(b) If the maximum energy given to an electron during Compton scattering is 30 keV, what is the energy of the incident photon (in keV)? (show the calculations, and you can use the Compton scattering formula directly)
- Please write down the answers briefly:
  - (7%) What is the wavelength of a neutron with energy of 0.025 eV?
  - (7%) For an excited atom that radiates with a lifetime  $1.0 \times 10^{-8}$  s, estimate the line width  $\Delta f$  of light emitted by the decay of this excited state. (in Hz)
  - (8%) An  $\alpha$  particle of mass  $m_\alpha$  and speed  $v_\alpha$  strikes a stationary proton with mass  $m_p$ . If the collision is elastic and head-on, show that the speed of the  $\alpha$  particle after the collision is given by?
- Please write down the answer briefly:
  - (4%) In the atomic hydrogen and hydrogen-like ions, we expressed the wavefunctions into four quantum numbers. Please write down the full name of these four quantum numbers both in English and Chinese.
  - (4%) In the atomic hydrogen and hydrogen-like ions, for the L shell of atomic shell, what are those possible quantum numbers (in all four quantum numbers) in this shell.
  - (2%) Please write down the electron configuration of a carbon ( $Z=6$ ) atom.
  - (2%) Please write down the electron configuration of an iron ( $Z=26$ ) atom.
  - (2%) Please write down the sequence of ionization energy of electrons of the following atoms (from the smaller to larger): Ne, Na, Xe, Cs.
  - (2%) Please write down the sequence of atomic volume of the following atoms (from the smaller to larger): Ne, Na, Rb, Cs.
  - (2%) The  $K_\alpha$  X-ray is emitted in the transition from excited shell to ground shell. Please tell me which excited shell to which ground shell. Write down the name of the shell.
  - (2%) The  $K_\beta$  X-ray is emitted in the transition from excited shell to ground shell. Please tell me which excited shell to which ground shell. Write down the name of the shell.

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5. Explain briefly the following terminologies:
- (4%) Selection rules in the transition of fluorescence emission of an excited atom.
  - (4%) Hund's rule for the electron spins.
  - (4%) Zeeman effects.
  - (4%) Larmor Precession.
  - (4%) Bohr Magneton
6. (10%) A small object of mass 0.1 mg is confined to move between two rigid walls separated by 1.00 mm. Please calculate the minimum energy of this object. This energy also called zero-point energy.