

國立清華大學 107 學年度碩士班考試入學試題

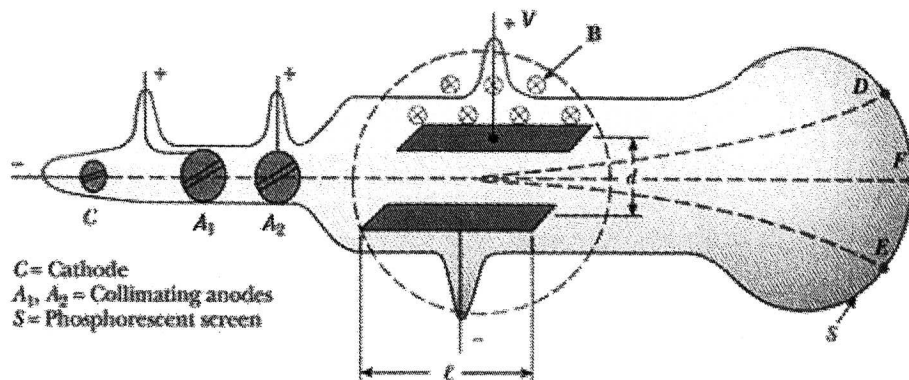
系所班組別：聯合招生 (0598)

考試科目 (代碼)：近代物理 (9802)

共 2 頁，第 1 頁 \*請在【答案卷】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>. 1 mole =  $6.02 \times 10^{23}$

- (10%) The sun radiates about  $4.0 \times 10^{26}$  Joules of energy into space per second. If the mass of the sun is  $2.0 \times 10^{30}$  kg, how long (in years) can the sun survive if the energy release continues at the present rate?
- (10%) The peak intensity of the light spectrum from the sun (surface temperature 5800 K) corresponds to a wavelength of 580 nm. For an object at temperature 2000 K, what is the wavelength of the peak intensity of the emitted spectrum of this object?
- (10%) How Millikan improved the method to measure the electron charge as compared to the method used by Thomson?
- (10%) The first three Balmer series of spectral lines for hydrogen ( $H_\alpha, H_\beta, H_\gamma$ ) have wavelengths of 656.3, 486.1, and 434.1 nm, respectively. Based on this information, derive the wavelength of the fourth spectral line of the Balmer series ( $H_\delta$ ).
- (10%) (a) Write down the force balance equation of  $E$  and  $B$  fields in the Thomson's experiment for measuring the charge to mass ratio of electron when the deflection force induced by the  $E$  field is balance by the  $B$  field. The horizontal velocity of the incoming electrons is  $v_x$  when the electrons enter the region with  $E$  and  $B$  fields. (b) Derive the equation for the deflection angle when there is an  $E$  field but zero  $B$  field. ( $E = V/d$ )



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6. (6%) Please write down the electron configuration of U ( $Z=92$ ), and the  $U^{4+}$  and  $U^{6+}$ . (hint: the electron configuration of Rn ( $Z=86$ ) is  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6$ )  
The U is one of actinides (with Ac ( $Z=89$ ); Th ( $Z=90$ ); Pa ( $Z=91$ )).
7. (4%) Please explain why  $U^{4+}$  and  $U^{6+}$  is most common U ion in the nature? Hint: from the electron configuration.
8. Please write down the answers to the following questions briefly:
- (1) (4%) In the atomic hydrogen and hydrogen-like ions, we express the wavefunction into four quantum numbers. Please write down the full names of these four quantum numbers both in English and Chinese.
  - (2) (4%) What is the Hund's rule for the electron spins.
  - (3) (4%) What is the Zeeman effect.
  - (4) (4%) What is the Larmor precession.
  - (5) (4%) What is the selection rule in the transition of fluorescence emission of an excited atom?
  - (6) (2%) The electrons in a multi-electron atom forming LS coupling and jj coupling. Which coupling is dominated when the atomic number  $Z$  is large ( $Z > 58$ )?
  - (7) (2%) Please write down at least two names of different types of accelerators with energy higher than 3 MeV according to their technology. (please do not write electron accelerator, ion accelerator or proton accelerator)
  - (8) (2%) Please write down the sequence of ionization energy of electrons of the following atoms (from the low to high): Ne, Na, Xe, Cs.
  - (9) (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 both shells (excitation and ground shell) in term of 1s, 2p, 3d...
  - (10) (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 both shells (excitation and ground shell) in term of 1s, 2p, 3d...
9. If we use the 8 keV synchrotron X-rays to do the diffraction experiment with Si(111), what is the diffraction angle,  $\theta$ ,  $2d_{hkl} \sin \theta = \lambda$ ? (5%) If we use 25 meV neutrons to do the same experiment, what is the diffraction angle? Assume the lattice constant of Si  $a = 0.357$  nm, and the lattice spacing of (111) is  $d_{hkl} = a / (h^2 + k^2 + l^2)^{1/2}$ . (5%)