注意：考試開始鈴響前，不得翻閱試題，
並不得書寫、畫記、作答。

國立清華大學 112 學年度碩士班考試入學試題

系所班組別：工程與系統科學系
丙組

科目代碼：3203

考試科目：近代物理

－作答注意事項－

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「▼ 由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 112 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 丙組(0532)

考試科目（代碼）：近代物理 (3203)

c=3.00x10^{8} m/s, k_B =1.38x10^{-23} J/K, h=6.63x10^{-34} J·s, e=1.60x10^{-19} C, Mass of electron: 9.11x10^{-31} kg; mass of proton 1.67x10^{-27} kg

1. The X-ray photoemission spectroscopy can be used to measure the composition of materials and valence state of specific element. If I have a synchrotron X-ray with photon energy of E_{hv}=1254 eV, incident on a conductive Co compound with oxidation state of 2^+. The binding energy of Co K-shell is 7709 keV; L-shell energies are 926 eV, 794 eV and 779 eV for L_I, L_{II} and L_{III} edges, respectively. The work function (i.e. The energy needed for an electron leaving the surface of material) is 3 eV. Please tell me what are the energies of the major photoelectrons, E_e? (5 points) What is the momentum of these photoelectrons? (5 points) Hint: E_e=E_{hv}-binding energy -work function. The rest mass of an electron is 9.11x10^{-31} kg. h=6.63x10^{-34} Js.

2. I want to do a neutron diffraction on Ge(111) d-spacing, d_{hkl}, the energy of neutron is E=0.020 eV. What is the diffraction angle θ for Ge(111)? (10 points) The lattice constant of Ge is a=0.565 nm. Hint: $2d_{hkl}\sin\theta=\lambda$, $d_{hkl}=a/\mathrm{sqrt}(h^2+k^2+l^2)$, $\lambda=h/\mathrm{sqrt}(2mE)$, where "sqrt" means the square root, and h,k,l are Miller indices of a crystal lattice in reciprocal space. The rest mass of a neutron is 1.67x10^{-27}kg.

3. In the positron emission tomography experiment, a positron emitter nuclide is used. During positron annihilation process, the slowing down (down to almost zero energy) positron collides with an electron (at rest) of the tissue. The mass disappeared and two gamma rays are emitted with angular correlation of 180 degrees. Please tell me what is the energy of each gamma ray. (10 points) Note that there are two gamma rays emitted, please write down the energies of both gamma rays.

4. Please tell me why the light emission from 2s to 1s is not possible? (5 points) If the light emitted from 2p to 1s state is possible, and the energy width of 2p state is 2 eV, please tell me what is the decay time of the light emission,. Hint: please use the Heisenberg uncertainty principle. (5 points)

5. In the excited hydrogen-like spectrum experiment, the highest peak with energy of 3.7 eV was assigned as a transition from n=3 to n=2. Please calculate the energy difference between n=2 and n=1. (10 points) Note that the hydrogen-like excited system is not hydrogen. It is more like He^{+}, Li^{+2} system. Therefore, you cannot use hydrogen binding energy value of -13.6 eV.

6. What is the relativistic kinetic energy of electron in a synchrotron if the electron velocity is 0.999c of light velocity (c is the light velocity) ? (5 points) The relativistic kinetic energy of electron in the Taiwan Photon Source (TPS) of National Synchrotron Radiation Research Center in Hsinchu is 3 GeV, please calculate the velocity of electron (relative to the light velocity) inside this TPS synchrotron. (5 points) Hint: the relativistic kinetic energy $K=\gamma mc^2-mc^2$.

7. In a cold fusion reactor, after the deuterium + tritium reaction, give off a neutron and a helium atom. What is the energy of neutron, if there is no gamma ray and X-ray are emitted in the fusion reaction and helium is in ground state. (10 points) The mass of deuterium, tritium, neutron and helium are 2.014102 amu, 3.016049 amu, 1.008665 amu and 4.002603 amu, respectively. 1 amu=1.67×10^{-27}kg.

8. Please write down the following questions briefly? (each sub-question is 2 points)
   8-1 How many electrons in 3-d orbitals of a transition elements if all the 3-d orbitals are full?
   8-2 What is the electron configuration of Fe^{2+} (Z=26)?
   8-3 What is magnetic moment of Fe^{2+} atom if each electron spin is 1/2.
   8-4 What is the name of the characteristic X-ray, when the K-shell of electron was knocked out by high energy electron, and the L-shell electron comes to fill up the hole of K-shell?
   8-5 What is the name of the characteristic X-ray, when the K-shell of electron was knocked out by high energy X-ray, and the M-shell electron comes to fill up the hole of K-shell?

9. Please answer the following questions briefly: (each sub-question is 2 points)
   9-1 Which number was verified in the black body radiation experiment?
   9-2 What is the new discovery in the Stern-Gerlach experiment?
   9-3 What is the new discovery of Millikan oil drop experiment?
   9-4 In which discovery, Albert Einstein got the Nobel prize?
   9-5 What is the direct confirmation of physical property of atoms by the Franck-Hertz experiments?

10. Answer the following questions briefly: (each sub-question is 2 points)
   10-1 Please tell me why in a sample vacuum chamber is needed during the electron diffraction, while in neutron or X-ray diffraction, a sample vacuum chamber is no longer need?
   10-2 Why an iron metal is ferromagnetic while an aluminum metal is not?
   10-3 With what kind of method, the temperature of sun can be determined to be 5800 K?
   10-4 With which experimental apparatus, we can determine the gas molecules in the sun consists of helium atoms.
   10-5 Which element among all the 91 natural elements has the lowest electron ionization energy?