國立成功大學107學年度碩士班招生考試試題

系　　所：物理學系

考試科目：近代物理學

考試日期：0206，節次：3

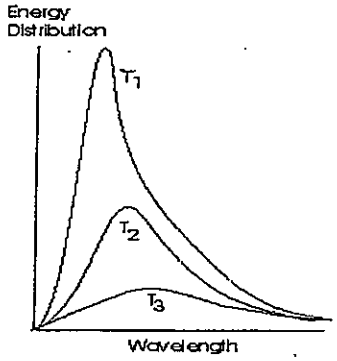
※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

注意: 可以用中文或英文作答。

(1-4 題為單選題，每一題 5 分。請直接寫下答案，答錯不倒扣。)

1. The figure below illustrates the energy distribution as a function of wavelength from a black body radiation with three different temperatures. If $T_1 = 4000$ K and the maximum occurs at 725 nm, what is the corresponding maximum at $T_3 = 2000$ K?

(a) 5800 nm (b) 2900 nm (c) 2175 nm (d) 2050 nm (e) 1450 nm



2. Same as the previous situation, the black body with T_1 has a radiation power of about 160 kW. What is the radiated power for the black body with T_3?

(a) 10 kW (b) 20 kW (c) 40 kW (d) 80 kW (e) 113 kW

3. How much energy in the order of magnitude (數量級) would have to be supplied to a nucleus of $^{24}Cr^{52}$ in order to split it into two identical fragments? The atomic mass of $^{24}Cr^{52}$ is 51.94 u, and that of $^{12}Mg^{26}$ is 25.983 u, where $u = 1.66\times10^{-27}$ kg is the atomic mass unit.

(a) 10 keV (b) 100 keV (c) 1 MeV (d) 10 MeV (e) 100 MeV

4. Which experiment provided strong evidence for supporting de Broglie's hypothesis of matter waves?

(a) Franck-Hertz experiment (b) Stern-Gerlach experiment (c) Davison-Germer experiment

(d) Compton scattering experiment (e) Photoelectric effect experiment

(5-12 題為問答題，每一題 6 分。請直接寫下答案，無需列計算過程。)

5. According to Hund's rule, what is the total spin quantum number S for the ground state of nitrogen (N) atom? How many magnetic quantum states will be found if we put nitrogen atoms in a magnetic field?

6. For a photoelectric effect experiment, the kinetic energy of the electron emitted from the surface of a metal is measured to be 2 eV. If the work function of the metal is 0.5 eV, what is the wavelength of the light used in this experiment?

7. Based on Bohr's model for a hydrogen atom, what is the emitted energy in eV for an electron moving from an orbital with quantum number $n = 2$ to another orbital with quantum number $n = 1$?

8. The de Broglie wavelength for a moving electron is equal to 100 times of the Compton wavelength. Within the non-relativistic limit, what is the speed of this moving electron?

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9. Two degenerate electronic states can be removed by applying an external magnetic field. If the photon energy of 0.1 meV is absorbed for the two-level transition, what is the order of magnitude (數量級) of the magnetic field used in this experiment?

10. Based on Bohr's model for a hydrogen atom, what is the order of magnitude (數量級) of the magnetic field at the center of the atom produced by the orbital electron with a Bohr radius?

11. For an electron moving in a one-dimensional simple harmonic oscillator potential, if the radiated frequency due to the electron from the first excited state to the ground state is ν_0, what is the frequency for the radiation from the second excited state to the first excited state? Express your answer in terms of ν_0.

12. What is the approximate value of the fine-structure constant (精細結構常數)? What is the unit (單位) or dimension (因次; 量綱) of this constant?

(13-14題為計算題。需詳列計算過程，僅列式正確或僅答案正確，則得部份分數。)

13. For an electron moving within an infinite square well confined between $x = -a/2$ and $+a/2$, the wave function for the ground state energy is described as $\Psi(x,t) = B\cos(\pi x/a)\exp(-iEt/\hbar)$ where B is a real constant and E is the total energy of the electron. (a) Find the relationship between B and the width a. (b) Compute the expected value of the position $\langle x \rangle$. (c) Calculate the expected value of the momentum $\langle p \rangle$. (d) Evaluate the ground state energy by solving the Schrodinger equation. (e) What is the eigen-energy for the first excited state? (第(e)小題請直接寫下答案，無需列計算過程。) Express your answers in terms of the mass of the electron m, the width of the well a, and the reduced Planck constant $\hbar$. **(20分; 每一小題4分)**

14. A system with N distinguishable atoms which are distributed over two energy levels $\varepsilon_1 = 0$ and $\varepsilon_2 = E_0$. (a) Compute the energy of this system at a temperature $T = E_0/2k$. (b) Find the specific heat of the system at $T = E_0/2k$. Express your answers in terms of N, E_0, and the Boltzmann constant k. **(12分)**

- Bohr radius $a_B = 0.53 \times 10^{-10}$ m
- Bohr magneton $\mu_B = 0.93 \times 10^{-23}$ amp-m^2 (or joule/tesla)
- Orbital g factor of the electron $g = 2$
- Magnetic permeability constant $\mu_0 = 4\pi \times 10^{-7}$ webb/amp-m (or henry/m)
- Electron mass $m = 9.11 \times 10^{-31}$ kg
- Planck constant $h = 6.63 \times 10^{-34}$ J sec
- Rydberg constant $R_H = 1.097 \times 10^7$ m^{-1}
- Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K
- Light speed $c = 3 \times 10^8$ m/s
- $\cos^2\theta = (1 + \cos 2\theta)/2$
- $e^{+1} \sim 2.718$; $e^{-1} \sim 0.368$; $e^{-2} \sim 0.135$;