Boltzmann constant $k=8.617 \times 10^{-5}$ eV/K

Electron mass $m_e=0.511$ MeV/c^2

Planck's constant $h=4.136 \times 10^{-15}$ eV · s

*計算題需計算過程，無計算過程者不予計分

1. (10 pts) Using Boltzmann probability distribution to estimate the ratio of the probability of finding an H-atom in the state $n = 2$ to the probability of finding it in the ground state $n = 1$ at room temperature.

2. (10 pts) Show that the total energy density in a blackbody cavity is proportional to T^4 from the Planck's law $u(\lambda) = \dfrac{8\pi hc\lambda^{-5}}{e^{\frac{hc}{\lambda k_B T}} - 1}$.

3. (10 pts) Most excited atomic states decay and emit a photon. For atomic transitions, t is of order of 10^{-8} sec. Evaluate the minimum uncertainty in the frequency of the emitted photon.

4. (10 pts) In a NaCl crystal, there is a family of planes 0.252 nm apart. If the first-order maximum is observed at an incidence angle of 18.1°, what is the wavelength (unit in nm) of the X-ray scattering from this crystal?

5. (10 pts) Suppose we have a single particle of mass m confined to within a region $0 < x < L$ with potential energy V = 0 bounded by infinitely high potential barriers, i.e. $V = \infty$ for $x < 0$ and $x > L$. The wave function of this potential barrier has the form of $\Psi_n(x)e^{-iE_n t/\hbar}$. What is the probability distribution function at $x < 0$ and $x > L$.

注意:背面有試題

6. (10 pts) One of twins wants to travel to the nearest star from Earth by taking spaceship. One leaves on his 10th birthday and plans to return on Earth on his 20th birthday. (a) Assuming spaceship keeps a constant speed without stopping, what is the speed of spaceship? (b) How old will be another twin on Earth when his brother returns?

7. (10 pts) Typically, a person can detect light with a minimum intensity of 4.0×10^{-11} W/m^2. For light of this intensity and wavelength of 600 nm, how many photons enter the eye per second if the pupil is open wide with a diameter of 9 mm?

8. (10 pts) If a nanowire is 1 μm long and at a temperature of 10 K, consider an electron moving in the nanowire as a one-dimensional infinite square-well potential and with an average kinetic energy of gas molecule at 10 K. (a) What is the lowest possible energy of the electron? (b) What is the quantum number of electron moving in the nanowire?

9. (10 pts) At T=0 K, what fraction of electrons have energy lower than the average energy?

10. (10 pts) For an H-atom with principal quantum number n, (a) what is the total degeneracy? (b) Find the magnetic moment at the largest possible orbital angular momentum based on Bohr's model and Schrodinger equation.

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