國立中央大學 105 學年度碩士班考試入學試題

所別： 光電科學與工程學系 碩士班 不分組(一般生)　　共 2 頁 第 1 頁

科目： 近代物理

本科考試可使用計算器，廠牌、功能不拘　　＊請在答案卷(卡)內作答

Planck constant $h=6.6\times10^{-34}$ J-s.

1. What is the number density N/V for helium to occur Bose-Einstein condensation at room temperature (300 K)? (10%)
2. If N particles are put in a system with only two possible states, $E_1=0$, and $E_2=E_0$. The distribution function is $f_i=A*exp(-E_i/kT)$. Compute the average energy and heat capacity (10%).
3. If a particle with mass m is in the simple harmonic oscillator ground state, with classical turning points at ±A. Compute the expectation value of the kinetic energy and total energy. (10%)
4. If a gamma ray with the wavelength of *1.76 pm* is used for Compton scattering measurement, what is the maximum kinetic energy given to electron? (10%)
5. If a particle M has total energy $4mc^2$ and decays into two identical particles moving along the direction of M, each of mass m, find the velocities of the two decay particles in the lab frame. (10%)
6. (a) If the maximum energy transferred to a free stationary electron during Compton scattering can accelerate it to a relativistic mass of $\frac{5}{3}m_0$ (where m_0 is the electron rest mass), what are the wavelengths of the incident photon and the recoil electron? (6%)
   (b) Calculate the group and phase velocities of the recoil electron. (6%)
   (c) Give at least three interaction situations that the Compton scattering effect might not be obvious or detectable. (4%)
7. A lighthouse with a 800 W lamp emitting at yellow light with a peak wavelength of 590 nm is 10 km far away from you in a boat. Estimate the photon flux (photon number per second per unit area (cm^2)) of the 590 nm light (occupying 20% of the total emission energy) entering your eyes, assuming negligible attenuation of the light along the way. (5%)

注意：背面有試題

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8. (a) Sketch and explain experimental setups for measuring the absorption and emission spectra of atomic hydrogen. (5%)
   (b) Why the observed spectral lines are not perfectly sharp? Give at least three possible mechanisms responsible for the line broadening. (4%)
   (c) Explain why the selection rule for allowed transitions in Hydrogen is $\Delta l=\pm 1$ (where l is the orbital angular momentum quantum number). Show this selection rule leads to the possible transitions for Δj is 0, ±1 (where j is the total angular momentum quantum number). Write down all the possible transitions in H_α line (using "term symbol", i.e., $n\,^S L_j$ to represent the energy levels). (7%)
   (d) Calculate the ratio of intensities of the spectral lines from P states to S state in H_α line. (4%)
   (e) In x-ray spectra measurement, Henry Moseley found the relationship between the characteristic frequency f of (say, K_α) x-ray and the atomic number Z of the probed atom is $f \propto (Z-\delta)^2$, where $\delta \sim 1$, which exhibits a small discrepancy with what is predicted as $f \propto Z^2$. Please explain what has caused the discrepancy. (4%)
9. Design an experiment to observe and measure the phenomenon of the gravitational deflection of light via the sun. (5%)

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