國立中央大學九十一學年度碩士班研究生入學試題卷

所別：太空科學研究所　不分組　科目：近代物理　共 1 頁　第 1 頁

1. (a) What's the difference between the Doppler effect in sound and the Doppler effect in light ? (3%)
   (b) Derive the formula for the Doppler effect in sound. (4%)
   (c) Derive the formula for the Doppler effect in light. (8%)
   (d) Show that when the relative speed $v << c$, the formulas for the Doppler effect both in light and in sound for a source receding from an observer, all reduce to the same form. (5%)

2. (a) Show that why the photoelectric effect can take place only when photon strike bound electrons. (10%)
   (b) Suppose you have a source that emits a beam of light at some frequency f that impinges on a metal plate. What happens to the energy of the photoelectrons that are emitted when you are moving the source closer to the plate ? (5%)
   (c) How to find Planck's constant by doing photoelectric experiments. (5%)

3. An oscillator of mass m moves in a one-dimensional potential
   $$V(x) = \frac{1}{2}\kappa x^2,$$
   (a) What is its time-dependent Schrödinger equation? (5%)
   (b) Show that the wave function $\Psi(x) = A\exp(-x^2/\sigma^2)$ is a stationary state of the oscillator. (5%)
   (c) Determine the uncertainty of position Δx of the oscillator at the state in (b). (10%)
   (d) Determine the energy of the oscillator and the uncertainty of momentum at the state in (b). (10%)

4. (a) Sketch the normal Zeeman splitting for the transition of the $4p$ and $3d$ energy levels of a hydrogen atom. (10%)
   (b) What is the splitting between these energies. (5%)

5. The number of particles in each state of energy ε at the temperature T is called the distribution function. There are three distribution functions, $f(\varepsilon) = Ae^{-\varepsilon/kT}$ for a classical gas, $f(\varepsilon) = 1/(Be^{\varepsilon/kT} - 1)$ for a gas of bosons, and $f(\varepsilon) = 1/(Ce^{\varepsilon/kT} + 1)$ for a gas of fermions, where A, B and C are normalization constants.
   (a) At the same temperature, which gas will it exert the greatest pressure? The least pressure? Why? (10%)
   (b) What is the average energy of a photon gas at $T = 0K$? (5%)