國立中央大學九十學年度碩士班研究生入學試題卷

所別：大氣物理研究所　不分組　科目：近代物理學　共 1 頁 第 1 頁

1. It is possible for the electrons in a medium to move at a speed faster than the speed of light. Does it contradict special relativity? (5%)

2. (a) The Doppler effect in sound varies depending on whether the source, or the observer, or both are moving. Does it violate the principle of relativity? (5%)
   (b) An observer moves at a speed u perpendicular to a line between him and a light source. The source emits a wave of light with frequency ν_0.
   What is the observed light frequency ν? (5%)

3. The temperature of the sun's surface is about $6000K$ and the sun's radius is $7\times10^{8}m$. Light from the sun arrives at the earth, an average of $1.5\times10^{11}m$ away. Assume that the sun radiates as a blackbody, and that the earth acts as a blackbody as both absorber and emitter.
   (a) Calculate the surface temperature of the earth. (5%)
   (b) Assume sunlight is monochromatic with wavelength $6\times10^{-5}cm$. How many photons per cubic meter are there near the earth? (5%)
   [hint: the Stefan-Boltzmann constant is $5.67\times10^{-8}Wm^{-2}K^{-4}$ and the Planck constant is $6.63\times10^{-34}J\cdot\sec$]

4. Show that a free electron cannot absorb a photon. (10%)

5. The size of a typical atom is $10^{-8}cm$. Estimate the energy of an electron confined in an atom. (5%)

6. For a particle of rest mass m and kinetic energy E_k,
   (a) Find the de Broglie wavelength of the particle. (5%)
   (b) If a photon has the same wavelength, can anything be said about how their momenta compare? (5%)

7. A particle has mass m in an infinite one-dimensional potential well of width a,
   (a) Calculate the expectation values of linear momentum p and p^2 in the ground state and first excited state. (10%)
   (b) If the particle is in the first excited state, calculate the probability that the particle will be found between $x=a/3$ and $a/2$, and compare it with the classical prediction. (10%)
   (c) If the particle is in excited state with large quantum number ($n>>1$). Calculate the probability that the particle will be found in an interval Δx and compare it with the classical prediction. (5%)

8. If we do not consider electron spin, we use three quantum numbers to describe an atomic electron, why? (5%)

9. How many electrons can occupy a d subshell? (5%)

10. 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 an electron gas at $T=0K$? (5%)