# Modern Physics

2002/04

Physical constants:

*Avogadro's number:* $N_a=6.02\times10^{23}$ *particles/mol*

*Coulomb constant:* $k=8.987\times10^{9}\ N\cdot m^2/C^2$

*Mass of electron:* $m_e=9.1\times10^{-31}$ *Kg*

*Mass of neutron:* $M_n=1.674929\times10^{-27}$ *Kg = 939.6 MeV*

*Mass of unit:* $u=1.66\times10^{-27}$ *Kg*

*Speed of light:* $c=299792458$ *m/s*

*Fine structure constant:* $\alpha=7.297\times10^{-3}$

*Permeability of free space:* $\mu_0=4\pi\times10^{-7}\ N/A^2$

*Boltzmann's constant:* $k=1.38\times10^{-23}$ *J/K*

*Fundamental charge:* $e=1.6\times10^{-19}$ *C*

*Mass of proton:* $M_p=1.672623\times10^{-27}$ *Kg = 938.3 MeV*

*Mass of pion:* $M_{\pi^-}=139.6$ *MeV*

*Planck's constant:* $h=6.6\times10^{-34}\ J\cdot s$

*Constant of gravitation:* $G=6.67\times10^{-11}N\cdot m^2/Kg^2$

*Gas constant:* $R=8.3\ J/mol\cdot K$

**Problem 1 (5%)** What is the zero point energy in a simple harmonic oscillator with mass *m* and spring constant *k*. _____.

**Problem 2 (5%)** Write down the Lorentz transformation of two coordinate systems, S'(x', y', z', t') and S(x, y, z, t), that the origins are coincident at time t = t' = 0 and S' is moving, relative to S, with speed **u** along the x (or x') axis and with the y' and z' axes parallel, respectively , to the y and z axes. (x', y', z', t') = _____.

**Problem 3 (5%)** As describe in problem 2, write down the velocity transformation.
$(v'_x, v'_y, v'_z)$ = _____.

**Problem 4 (5%)** Why is it extremely difficult to observed the Compton effect using visible light?
_____.

**Problem 5 (5%)** What conservation laws (if any) are violated by the reaction, $n \rightarrow p + \pi^-$.
lepton number : _____, charge : _____,
baryon number : _____, energy conservation : _____.

**Problem 6 (5%)** Briefly describe the Meissner effect in a superconductor. _____.

**Problem 7 (5%)** Explain why, physically, you would expect the mean free path of electrons in a metal to decrease as the temperature increases. _____.

(背面仍有題目,請繼續作答)

**Problem 8 (5%)** Consider the dipole allowed transitions between a pair of doublet energy states in sodium (Na), write down the possible transitions of $^2D_j \leftrightarrow {}^2P_j$. _____.

**Problem 9 (5%)** In which way would a broken holographic film (1/3 left) affect its image while reconstruction? _____.

**Problem 10 (5%)** Write down the conditions of the wave function solved from the Schrödinger equation to be considered acceptable. _____.

**Problem 11 (20%)** (A) What nonclassical postulates were proposed by Niels H. D. Bohr in order to solve the observed spectrum of hydrogen? (5/20)

(B) Derive the quantization radius $r_n$ and energy $E_n$ of hydrogen atoms with Bohr's postulates. (10/20)

(C) What are the deficiencies of the Bohr model?(5/20)

**Problem 12 (15%)** The Royal Swedish Academy of Sciences has decided to award the 1997 Nobel Prize in Physics jointly to Professor Steven Chu, Professor Claude Cohen-Tannoudji, and Dr. William D. Phillips, for development of methods to cool and trap atoms with laser light.

(A) What is the mechanism for laser light to cool and trap neutral atoms? Could we use an intensified tungsten light? (5/15)

(B) What would be the speed of free hydrogen atoms when the temperature is one-millionth of a degree Kelvin (termed 1 μK, microkelvin)? (5/15)

(C) What are the advantages to study the atoms at ultracold temperature? (5/15)

**Problem 13 (15%)** The ground state wave function of hydrogen atoms is $\Psi_{100} = C_{100} e^{-Zr/a_0}$.

(A) Determine the constant $C_{100}$. (5/15)

(B) At what value of r has the most probability to find the electron of the ground state hydrogen? (10/15)