本試題是否可以使用計算機：☑可使用 ，☐不可使用 （請命題老師勾選）

Physical constants:

Speed of light: c =3.00x10^{8} m/s

Planck's constant: h =6.6x10^{-34} J·s

Fundamental Charge: e=1.60x10^{-19} C

Mass of electron: m_e = 9.1x10^{-31} kg

Mass of unit: u=1.66x10^{-27} kg

c^2=931.5 MeV/ u

1. (10%) The solar constant (=1353 W/m^2) is defined as the solar energy falling per unit time at normal incidence on a unit area at the earth. Take the distance from the sun to the earth as 1.5x 10^{11} m and the diameter of the sun as 1.39x10^{9} m.
   (a) Calculate the rate of energy generation of the sun.
   (b) The surface temperature of the sun is around 6000 K. Determine the Stefan-Boltzmann constant in Stefan's law from the data above.

2. (16%) A γ-ray photon of 0.511 MeV strikes a free electron in metal. What is the possible process for this collision: photoelectric effect, Rayleigh scattering, Compton effect, or pair production? You need to briefly describe these effects and then give your reason.

3. (12%) Staring with the relativistic expression for the energy and momentum, and using the operators for E and P, formulate a one dimensional Schrödinger equation for a free particle, and solve it by separation of variables.

4. (10%) What are the Hund rules? Plot energy levels of 2p3d configuration in LS coupling.

5. (12%) The model of free electrons in metal is simplified model by assuming that the potential energy in metal is zero, and a potential barrier V_0 exists at the metal boundary. For a electron with the kinetic energy E, the work function ($V_0 - E$) is 4 eV. Estimate the approximate penetration distance Δx for the electron out of the metal surface.

(背面仍有題目,請繼續作答)

6. (15%) Two particles are moving inside a one dimensional system of length L. The quantum states for one particle is n=1 and for the other is n=2. Find the probability for both particles staying at the region $x=L/4 \pm L/20$, if they are (a) different particles and (b) identical particles, respectively.

7. (15%) (a) What differences exist in the classical (equipartition theorem) model, the Einstein model and the Deby model for estimating specific heat C_v of a crystalline dielectric solid?
(b) Evaluate the C_v at $T/\theta \ll 1$ and $T/\theta \gg 1$ by the Deby model, where θ is the Deby temperature.
(Note: $\int_0^\infty x^3 dx/(e^x-1) = \pi^4/15$)

8. (10%) The rotational absorption lines of $l=0 \rightarrow l=1$ for $C^{12}O^{16}$ and C^xO^{16} are 1.153×10^{11} Hz and 1.102×10^{11} Hz, respectively. Find the mass number x of the unknown C^x.