

參考用

Possibly useful constants:

$$G = 6.7 \times 10^{-8} \text{ dynes cm}^2 \text{ g}^{-2}; k = 1.38 \times 10^{-16} \text{ erg K}^{-1}; c = 3 \times 10^{10} \text{ cm s}^{-1}; h = 6.6 \times 10^{-27} \text{ erg s}$$

1.(10%) With basic Bohr theory,

- a. calculate the magnetic field experienced by the proton caused by an electron in its ground state of an hydrogen atom.
- b. estimate the energy of the hyperfine splitting of this state.

2.(5%) The volume of a perfect gas of N atoms is doubled, the energy being held constant. What is the change in entropy?

3.(10%) Derive the scattering cross section of a photon by a free electron in the classical approximation, given that the power radiated by an accelerating charge is

$$P = \frac{2e^2 a^2}{3c^3} \text{ erg/s.}$$

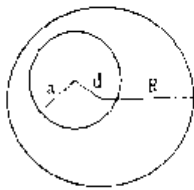
4.(5%) Construct the Lagrangian of a dipole whose opposite charges are of masses m_1 and m_2 and which is located in a homogeneous electric field E .

5.(10%) A spaceship is shot out from the earth into interstellar space straight to a star at a distance of D . Except for a short time at the beginning, the acceleration of the rocket a , as measured by the passengers, is constant throughout the journey. According to a clock inside the spaceship, how long will it take to get to the star?

6.(10%) A particle of mass m moves in a potential $V(r) = -V_0$ when $r < a$, and $V(r) = 0$ when $r > a$. Find the least value of V_0 such that there is a bound state of zero energy and zero angular momentum.

參考用

- 7.(10%) A long straight wire of radius R has a circular hole of radius a parallel to the axis of the wire but displaced from the center by a distance d . A uniform current I flows in the wire. Find the magnetic field everywhere in space.



- 8.(5%) The average density of hydrogen atoms in intergalactic space is about 1 per m^3 . Assuming an atomic diameter of 10^{-8} cm, estimate the mean free path.
- 9.(10%) N particles are distributed among three states with energy $E=0$, kt , and $2kt$, respectively. If the total equilibrium energy of the system is $500kt$, what is the value of N ? You do not need to arrive at a final answer in a numerical form, but should state clearly how you derive the answer.
- 10.(10%) Determine normalized wave function and the energy levels of a particle in a potential well V for which

$$V = \begin{cases} \infty & \text{for } x < 0 \text{ and for } x > a; \\ 0 & \text{for } 0 < x < a. \end{cases}$$

- 11.(5%) Explain the distinction between Fraunhofer and Fresnel diffraction.
- 12.(10%) Consider a hypothetical medium in which the angular momentum ω and wavenumber k of an electromagnetic wave are related by $\omega = k^2 + b$. What are the phase velocity and group velocity in the medium?