

## Physical constants:

Avogadro's number:  $N_a = 6.02 \times 10^{23}$  particles/molCoulomb constant:  $k = 8.987 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$ Mass of electron:  $m_e = 9.1 \times 10^{-31} \text{ Kg}$ Mass of unit:  $u = 1.66 \times 10^{-27} \text{ Kg}$ Speed of light:  $c = 299792458 \text{ m/s}$ Fine structure constant:  $\alpha = 7.297 \times 10^{-3}$ Permeability of free space:  $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$ Boltzmann's constant:  $k = 1.38 \times 10^{-23} \text{ J/K}$ Fundamental charge:  $e = 1.6 \times 10^{-19} \text{ C}$ Mass of proton:  $M_p = 1.67 \times 10^{-27} \text{ Kg}$ Planck's constant:  $h = 6.6 \times 10^{-34} \text{ J} \cdot \text{s}$ Constant of gravitation:  $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{Kg}^2$ Gas constant:  $R = 8.3 \text{ J/mol} \cdot \text{K}$ 

## 1. 解釋名詞

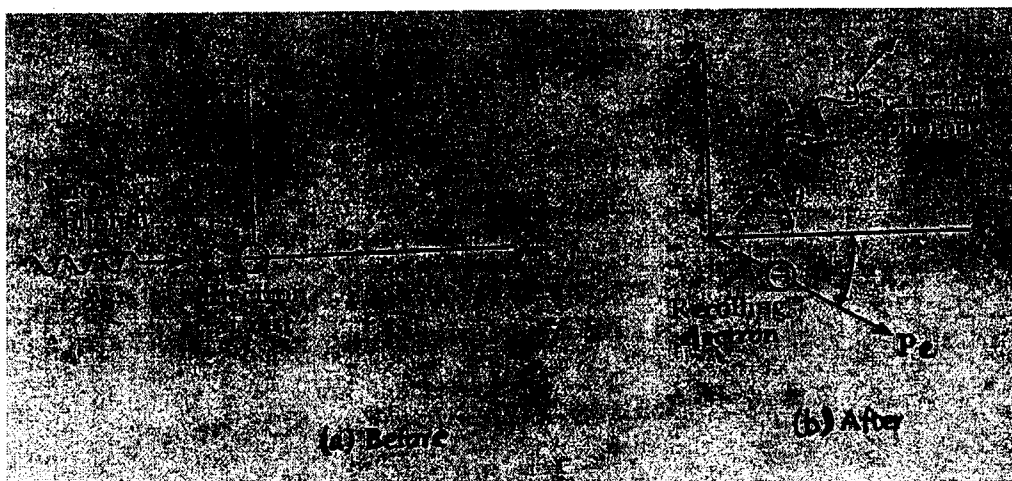
1. Photoelectric effect (5%)
2. Matter waves (5%)
3. The uncertainty principle (5%)

## 2. The Compton effect

- (a) Please describe the Compton effect (5%)
- (b) According to the chart below, please prove that: (15%)

$$\lambda_s - \lambda_0 = \frac{h}{m_0 c} (1 - \cos \theta).$$

where  $\lambda_0$  is the wavelength of incident photon;  $\lambda_s$  is the wavelength of scattered photon;  $m_0$  is the rest mass of electron.  $h$  is Planck's constant.  $c$  is light speed.



(背面仍有題目,請繼續作答)

## 3. The blackbody radiation

- (a) A certain blackbody has the peak of the radiation curve at a wavelength of  $8000 \text{ \AA}$  (埃). If the temperature is raised so that the total radiated energy is increased 16-times, at what wavelength will the new intensity maximum be found? (5%)
- (b) Find the ratio of the spectral radiation intensities of wavelengths  $\lambda_1 = 0.35 \text{ nm}$  and  $\lambda_2 = 0.7 \text{ nm}$  in the spectrum of a blackbody at temperature of  $6000\text{K}$ ? (10%)

4. A particle of charge  $q$  and mass  $m$  is subject to a uniform electrostatic field  $E$ .

- (a) Write down the time-dependent Schrödinger equation for this system. (5%)
- (b) Show that the expectation value  $\langle r \rangle$  of the position operator obeys Newton's second law of motion when the particle is in an arbitrary state  $\psi(r, t)$ , that is,  $m d^2\langle r \rangle/dt^2 = qE$ . (5%)
5. (a) Explain the normal and anomalous Zeeman effects. (10%)
- (b) Using the vector model of the atom, compare the magnitude of the total magnetic moment in the  $^3P_2$  state with the magnitude of the effective magnetic moment in the same state. (10%)

6.  $\psi(x, t)$  is a solution of Schrödinger equation for a free particle of mass  $m$  in one-dimension, and

$$\psi(x, 0) = A \exp(-x^2/a^2).$$

- (a) At time  $t = 0$  find the probability amplitude in momentum space. (10%)
- (b) Find  $\psi(x, t)$ . (10%)