Physical constants:

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

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

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

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

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

Mass of proton: $M_p=1.67\times10^{-27}$ *Kg*

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

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

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

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

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

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

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

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%)

$$\lambda_s-\lambda_0=\frac{h}{m_0c}(1-\cos\theta).$$

where λ_0 is the wavelength of incident photon; λ_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 Å (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 $\lambda_1 = 0.35$ nm and $\lambda_2 = 0.7$ nm in the spectrum of a blackbody at temperature of 6000K ? (10%)

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

(a) Write down the time-dependent Schrödinger equation for this system. (5%)

(b) Show that the expectation value $\langle \boldsymbol{r} \rangle$ of the position operator obeys Newton's second law of motion when the particle is in an arbitrary state $\psi(\boldsymbol{r}, t)$, that is, $m\, d^2\langle \boldsymbol{r} \rangle / dt^2 = q\boldsymbol{E}$. (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%)