14-2 在加热黑体过程中，λ_m 由 0.69×10^{-6} m 变化到 0.50×10^{-6} m，求辐出度变化到原来的几倍？

解：由斯特藩-玻耳兹曼定律 和维恩位移定律.

$$\frac{M_0(T_2)}{M_0(T_1)}=\frac{\sigma T_2^4}{\sigma T_1^4}=\frac{\left(\frac{b}{\lambda_2}\right)^4}{\left(\frac{b}{\lambda_1}\right)^4}=\frac{\lambda_1^4}{\lambda_2^4}=\left(\frac{0.69}{0.50}\right)^4=3.627.$$

14-4 单位时间内太阳发射到地球上每单位面积的辐射能量为 0.14 $J\cdot m^{-2}\cdot s^{-1}$, 假定太阳辐射的平均波长为 500 nm, 问这相当于每秒钟发射到地球表面每平方厘米上多少个光子?

解:

$$E = Nh\nu$$

$$N = \frac{E\cdot\lambda}{hc} = \frac{500\times10^{-7}\,cm \times 0.14\cdot J\cdot(10^{2}\,cm)^{-2}\cdot s^{-1}}{6.626\times10^{-34}\,J\cdot s\times3\times10^{8}\times10^{2}\,cm\cdot s^{-1}} = 3.52\times10^{8}\ cm^{2}\cdot s^{-1}$$

14-7 波长为 4.0×10^{-7} m 的单色光, 照射到逸出功为 2.0 eV 的金属材料上, 光传到单位面积上的功率为 $3.0 \times 10^{-9}\ \mathrm{W \cdot m^{-2}}$, 求 (1) 单位时间内单位面积上该金属发射的电子数; (2) 光电子最大初动能.

解: (1) $W\Delta t = Nh\frac{c}{\lambda}$

$$\frac{N}{\Delta t} = \frac{W\lambda}{ch} = \frac{3\times10^{-9}\times4\times10^{-7}}{3\times10^{8}\times6.63\times10^{-34}} = 6.03\times10^{9}$$

(2) $$E_{kom} = h\nu - A = 6.63\times10^{-34}\cdot\frac{3\times10^{8}}{4\times10^{-7}} - 2\times1.6\times10^{-19}$$

$$= 4.97\times10^{-19} - 3.2\times10^{-19} = 1.77\times10^{-19}\ \mathrm{J}$$

14-8 计算波长为 0.1 nm 的光子的能量、频率和质量.

解:

$$E = h\nu = h\frac{c}{\lambda} = 6.63 \times \frac{3\times10^{8}}{0.1\times10^{-9}} \times 10^{-34} = 1.99\times10^{-15}\ \mathrm{J}$$

$$\nu = \frac{c}{\lambda} = \frac{3\times10^{8}}{0.1\times10^{-9}} = 3\times10^{18}\cdot s^{-1}$$

$$m = \frac{E}{c^{2}} = \frac{1.99\times10^{-15}}{9\times10^{16}} = 2.21\times10^{32}\ \mathrm{kg}$$

14-12 根据玻尔氢原子理论计算氢原子中的电子在第一至第四轨道上运动的速度和这些轨道的半径.

解：

$$\begin{cases} V_1 = \dfrac{e^2}{2\varepsilon_0 h} = \dfrac{(1.6\times10^{-19})^2}{2\times 8.854\times10^{-12}\times 6.63\times10^{-34}} = 2.18\times10^{6}\ m/s. \\ r_1 = \dfrac{\varepsilon_0 h^2}{\pi m_e e^2} = \dfrac{8.854\times10^{-12}\times(6.63\times10^{-34})^2}{\pi\times(1.6\times10^{-19})^2\times 9.1\times10^{-31}} = 5.31\times10^{-11}\ m \end{cases}$$

$V_n = \dfrac{V_1}{n}$. $\quad V_2 = 1.09\times10^{6}\ m/s \quad V_3 = 7.27\times10^{5}\ m/s \quad V_4 = 5.45\times10^{5}\ m/s$

$r_n = n^2 r_1$. $\quad r_2 = 2.12\times10^{-10}\ m \quad r_3 = 4.79\times10^{-10}\ m \quad r_4 = 8.51\times10^{-10}\ m$

14-14 如用能量为 12.6 eV 的电子轰击基态氢原子时可能产生哪些谱线?

解: $E_1 = -13.6\ eV.$ $E_3 = -1.81\ eV$ $E_4 = -0.85\ eV.$

$\Delta E_3 = E_3 - E_1 = 11.79\ eV$

$\Delta E_4 = E_4 - E_1 = 12.75\ eV.$

谱: $E_3 \to E_2$ $\Delta E_{32} = -1.51 + 3.39 = 1.88\ eV$ $\lambda_{32} = \dfrac{hc}{E_{32}} = 661\ nm$

$E_3 \to E_1$ $\Delta E_{31} = -1.51 + 13.6 = 12.09\ eV$ $\lambda_{31} = \dfrac{hc}{E_{31}} = 103\ nm$

$E_2 \to E_1$ $\Delta E_{21} = -3.39 + 13.6 = 10.21\ eV.$ $\lambda_{21} = \dfrac{hc}{E_{21}} = 122\ nm$

14-17 求下列电子的德布罗意波长: (1) 从 5×10^{10} eV 加速器中加速的电子; (2) 速度为 $0.5c$ 的电子; (3) 总能量恰好等于其静态质量能两倍的电子.

解: (1) $\lambda = \frac{h}{p} = \frac{h}{\sqrt{\left(\frac{E_k}{c}\right)^2 + 2m_0E_k}} = 2.48\times10^{-17}$ m.

(2) $\lambda = \frac{h}{p} = \frac{h}{\frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}}} = 4.21\times10^{-12}$ m

(3) $E = E_k + m_0c^2$. $E = 2m_0c^2 \Rightarrow E_k = m_0c^2$

$$\lambda = \frac{h}{\sqrt{\left(\frac{E_k}{c}\right)^2 + 2m_0E_k}} = \frac{h}{\sqrt{3}\,m_0c} = 1.40\times10^{-12}\text{ m}$$

14-18 在戴维孙和革末实验中, 已知晶格常量 $d = 0.3$ nm, 电子经 100 V 电压加速, 求各极大值所在的方向.

解: $2d\sin\theta = k\lambda$

$$\lambda = \frac{h}{\sqrt{2m_e eU}}$$

$$\Rightarrow \sin\theta = \frac{k}{2d}\cdot\frac{h}{\sqrt{2m_e eU}} = k\cdot\frac{6.63\times10^{-34}}{6\times10^{-10}\cdot\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times10^{2}}} = 0.205\,k$$

$\sin\theta \in (-1, 1)$. $k = 4$.

$$\begin{cases} k=0 & \theta = 0^\circ \\ k=1 & \theta = 11.82^\circ \\ k=2 & \theta = 24.18^\circ \\ k=3 & \theta = 37.90^\circ \\ k=4 & \theta = 54.99^\circ \end{cases}$$