28. 量子物理(一)

1、C、 2、D 3、A.

4. B.

$$E_n = \frac{E_1}{n^2}, \quad E_1 = -13.6eV$$

$$h\nu = E_n - E_k = E_1\left(\frac{1}{n^2} - \frac{1}{k^2}\right)$$

巴耳末系，$k=2$，$n=3,4,5,\cdots,\infty$

$$\frac{hc}{\lambda} = 13.6eV\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

$$\lambda_{min} = \frac{hc}{13.6eV}\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)^{-1}$$

$$\lambda_{max} = \frac{hc}{13.6eV}\left(\frac{1}{2^2} - \frac{1}{3^2}\right)^{-1}$$

$$\frac{\lambda_{min}}{\lambda_{max}} = \frac{5}{9}$$

5、增加，2倍.

6、$E = h\nu = \frac{hc}{\lambda}$，$P = \frac{h}{\lambda}$，$m_\varphi = \frac{h\nu}{c^2} = \frac{h}{c\lambda}$

7. $$\underset{\frac{hc}{\lambda}}{\underset{\parallel}{h\nu}} = E_k + W = \frac{1}{2}mv^2 + h\nu_0$$

$$\Rightarrow v = \sqrt{\frac{2}{m}\left(\frac{hc}{\lambda} - h\nu_0\right)}$$

$$= 5.74 \times 10^5 \ m/s$$

8. $h\nu_0 + m_0c^2 = h\nu + mc^2$

$E_k = mc^2 - m_0c^2 = h\nu_0 - h\nu$

$\Rightarrow h\nu = \frac{hc}{\lambda} = h\nu_0 - E_k = 0.5\text{MeV} - 0.1\text{MeV}$

$\frac{hc}{\lambda} = 0.4\text{MeV}$, $h\nu_0 = \frac{hc}{\lambda_0} = 0.5\text{MeV}$

$$\frac{\Delta\lambda}{\lambda_0} = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{\lambda}{\lambda_0} - 1 = \frac{5}{4} - 1 = \frac{1}{4} = 0.25$$

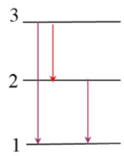
9、

1） 最高能激发到第n个能级，

此能级的能量为：$E_n = -\frac{13.6}{n^2}\text{eV}$，$E_n - E_1 = 12.6\,\text{eV}$，

$-\frac{13.6}{n^2}\text{eV} - (-13.6\,\text{eV}) = 12.6\,\text{eV} \Rightarrow n \sim 3.69$，$\Rightarrow$ 取$n = 3$

2）氢原子最高能激发到 n =3 的能级



如图所示，可发出3条谱线，
其中1条为可见光

10、

1） $\Delta\lambda = \lambda - \lambda_0 = \lambda_C(1 - \cos\theta) = \lambda_C(1 - \cos 90^\circ) = \lambda_C$

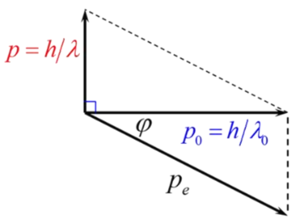
散射X射线波长：$\lambda = \lambda_0 + \lambda_C = 0.10243\,\text{nm}$

2） 根据能量守恒：$h\nu_0 + m_0c^2 = h\nu + mc^2$

反冲电子的动能为：

$E_k = mc^2 - m_0c^2 = h\nu_0 - h\nu = \frac{hc}{\lambda_0} - \frac{hc}{\lambda} = 4.7\times10^{-17}\,\text{J}$

根据动量守恒：$\vec{p}_0 = \vec{p} + \vec{p}_e$



$$\tan\varphi = \frac{p}{p_0} = \frac{h/\lambda}{h/\lambda_0} = \frac{\lambda_0}{\lambda} = 0.97628$$

$\varphi = 44.3^\circ$

$\varphi = \arctan(0.96645) = 44.0^\circ$

29. 量子物理(二)

1. A.

由不确定关系：$\Delta x \cdot \Delta p_x \geqslant \frac{\hbar}{2}$

$$\Delta p_x \geqslant \frac{\hbar}{2\Delta x}$$

不确定量 Δp_x 越小，动量 p_x 越精确

(A) 中 Δx 最大，Δp_x 最小，p_x 精确度最高.

2. A.

K壳层：$n=1$，$l=0,1,\cdots,n-1$，

$m_l = -l, -l+1, \cdots, +l$

$m_s = -\frac{1}{2}, +\frac{1}{2}$

3. $\lambda_p = \lambda_\alpha$，$p_p : p_\alpha = \frac{h}{\lambda_p} : \frac{h}{\lambda_\alpha} = 1:1$

动能 $E_p = \frac{1}{2} m_p v_p^2 = \frac{p_p^2}{2m_p}$

$E_\alpha = \frac{p_\alpha^2}{2m_\alpha}$

$m_\alpha = 4m_p$

$$\frac{E_p}{E_\alpha} = \frac{m_\alpha}{m_p} = \frac{4}{1}$$

4. ① 由 $\Delta x \cdot \Delta p_x \geqslant \frac{1}{2}\hbar \Rightarrow \Delta p_x \geqslant \frac{h}{4\pi} \cdot \frac{1}{\Delta x} = 1.06 \times 10^{-24}$ N·S

或 ② 由 $\Delta x \cdot \Delta p_x \geqslant h \Rightarrow \Delta p_x \geqslant \frac{h}{\Delta x} = 1.33 \times 10^{-23}$ N·S

①、② 都可以.

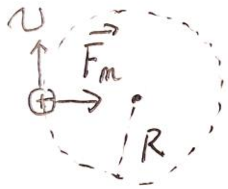
5. 2, $2(2l+1)$, $2n^2$

6. $L_z = m_l \hbar$, $m_l = 0, \pm 1, \pm 2$,

$L_z = 0, \pm\hbar, \pm 2\hbar$

7. α粒子: $q = +2e$, $m_\alpha = 6.64 \times 10^{-27}\ kg$

1)



$$F_m = qvB = 2evB = m_\alpha \frac{v^2}{R}$$

$$\Rightarrow m_\alpha v = 2eBR$$

$$\lambda_\alpha = \frac{h}{m_\alpha v} = \frac{h}{2eBR} = 9.98 \times 10^{-12}\ m$$

2) $$p = mv = m \cdot \frac{2eBR}{m_\alpha}$$

$$\lambda = \frac{h}{p} = \frac{m_\alpha}{m} \frac{h}{2eBR} = \lambda_\alpha \frac{m_\alpha}{m}$$

$$\lambda = 6.63 \times 10^{-34}\ m.$$

8.1)
$$\begin{cases} E_k = eU \\ E_k = E - E_0 = mc^2 - m_e c^2 \\ E_0 = 0.512\ \mathrm{MeV} \end{cases}$$

$$E^2 = P^2c^2 + E_0^2$$

$$\Rightarrow \quad p = \frac{\sqrt{E^2 - E_0^2}}{c} = \frac{\sqrt{E_k(E_k + 2E_0)}}{c}$$

$$p = \frac{\sqrt{eU(eU + 2E_0)}}{c}$$

$$\lambda = \frac{h}{p} = \frac{hc}{\sqrt{eU(eU + 2E_0)}} = 3.71 \times 10^{-12}\ m$$

2)
$$E_e = \frac{1}{2} m_e v^2 = \frac{p'^2}{2m_e} = eU$$

$$p' = \sqrt{2m_e eU}$$

$$\lambda' = \frac{h}{p'} = \frac{h}{\sqrt{2m_e eU}} = 3.88 \times 10^{-12}\ m$$

$$\frac{\lambda' - \lambda}{\lambda} = 4.67\%$$

9. $E_k = 1.0\,\text{keV} \ll E_0 = 0.512\,\text{MeV}$

不考虑相对论效应.

$$E_k = \frac{1}{2} m_0 v^2 = \frac{p^2}{2m_0} \Rightarrow p = \sqrt{2m_0E_k}$$

由 $\Delta x \cdot \Delta p_x \geqslant h$

$$\Delta p_x \geqslant \frac{h}{\Delta x}$$

$$\frac{\Delta p_x}{p} \geqslant \frac{h}{\Delta x \cdot p} = \frac{h}{\Delta x\sqrt{2m_0E_k}} = 38.8\%$$

(用：$\Delta x \cdot \Delta p_x \geqslant \frac{1}{2}\hbar = \frac{h}{4\pi}$

$$\frac{\Delta p_x}{p} \geqslant \frac{h}{4\pi\Delta x\sqrt{2m_0E_k}} = 3.1\%$$)

10、

1）第一激发态，n=2， $\psi_2 = \sqrt{\frac{2}{a}}\sin(\frac{2\pi x}{a}),\quad (0 \le x \le a)$

概率密度函数： $w(x) = |\psi_2|^2 = \frac{2}{a}\sin^2(\frac{2\pi x}{a}),\quad (0 \le x \le a)$

$\therefore$ 当 $\frac{2\pi x}{a} = (2k+1)\frac{\pi}{2}$ 有极大值，$\Rightarrow x = (2k+1)\frac{a}{4},\quad 0 \le x \le a$

粒子出现概率最大的位置： $x = \frac{a}{4},\ \frac{3a}{4}$

2）*n*=2时，波函数为: $\psi_1 = \sqrt{\frac{2}{a}}\sin(\frac{2\pi x}{a}),\quad (0 \le x \le a)$

概率密度函数： $w(x) = |\psi_1|^2 = \frac{2}{a}\sin^2(\frac{2\pi x}{a}),\quad (0 \le x \le a)$

$$\Rightarrow W = \int_0^{\frac{a}{2}} |\psi_1|^2 dx = \int_0^{\frac{a}{2}} \frac{2}{a}\sin^2(\frac{2\pi x}{a})dx = \int_0^{\frac{a}{2}} \frac{2}{a}\cdot\frac{1}{2}(1-\cos\frac{4\pi x}{a})dx$$

$$\Rightarrow W = \frac{1}{a}(x - \frac{a}{4\pi}\sin\frac{4\pi x}{a})\Big|_0^{\frac{a}{2}} = \frac{1}{2} = 50\%$$