1) $W_{kin} = 7{,}7\,MeV \qquad Z = 79$

a) Keine Abweichungen → nicht im Radius

$$W_{kin} = \frac{1}{4\pi\varepsilon_0}\,\frac{q_1 q_2}{r_{max}} \qquad q_1 = 79e \qquad q_2 = 2e \ (\alpha\text{-Teilchen})$$

$$\Rightarrow r_{max} = \frac{\cancel{4\pi\varepsilon_0 W_{kin}}}{} \; 2{,}95 \cdot 10^{-14}\ m$$

b) Kernradius: $r_k = 1{,}3 \cdot 10^{-15}\, A^{1/3} \qquad A = 197$

$$= 7{,}5 \cdot 10^{-15}\ m$$

2) $M = 12{,}011\ \frac{g}{mol} = (1-x) \cdot 12\ \frac{g}{mol} + x \cdot 13\ \frac{g}{mol}$

$$\Rightarrow x = 1{,}1\,\%$$

3) a) $n=2$ b) $n=4$ c) $n=1$ d) $n=3$ e) $n=5$

4) $E_n = \frac{R_\infty hc}{n^2} = \frac{13{,}6\,eV}{1^2} = 13{,}6\,eV$

5) a) $n=4$

$\ell = 0 \rightarrow m = 0$
$\ell = 1 \rightarrow m = 1, \dots -1$
$\ell = 2 \rightarrow m = 2, \dots -2$
$\ell = 3 \rightarrow m = 3, \dots, -3$

} 16 Lsg.

b) Nullstellen: $n - \ell - 1$

i) 1 ii) 1 iii) 0

6] $\langle p_{e1,2} \rangle = -e \iiint \psi_{2,0} \, z \, \psi_{210} \, dV$

$$\iiint \left(\frac{Z}{2a_0}\right)^3 \left(1-\frac{Zr}{2a_0}\right) e^{-\frac{Zr}{2a_0}} \frac{1}{\sqrt{4\pi}} \underbrace{r\cos\theta}_{z} \frac{1}{\sqrt{3}} \frac{Zr}{2a_0} \sqrt{\frac{3}{4\pi}} \cos\theta \, dV$$

$$= \frac{1}{\pi}\left(\frac{Z}{2a_0}\right)^3 \iiint \left(1-\frac{Zr}{2a_0}\right) e^{-\frac{Zr}{2a_0}} \frac{Zr}{2a_0} r^3 \cos^2\theta \, dr \underbrace{d\varphi}_{2\pi} \underbrace{d\theta}_{\frac{\pi}{2}}$$

$$= \pi \left(\frac{Z}{2a_0}\right)^3 \frac{Z}{2a_0} \int_0^\infty r^4 \left(1-\frac{Zr}{2a_0}\right) e^{-\frac{Zr}{2a_0}} dr$$

NR1

$$\Gamma \int_0^\infty r^4 e^{-\frac{Zr}{2a_0}} dr \quad \text{Subst } x = \frac{Zr}{2a_0} \Rightarrow r = \frac{2a_0 x}{Z}$$

$$\frac{dx}{dr} = \frac{Z}{2a_0} \Rightarrow dr = \frac{2a_0}{Z} dx$$

$$= \left(\frac{2a_0}{Z}\right)^5 \int_0^\infty x^4 e^{-x} dx = \left(\frac{2a_0}{Z}\right)^5 4! = 24 \left(\frac{2a_0}{Z}\right)^5 \; \lrcorner$$

NR2

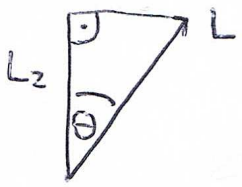
$$\Gamma \int_0^\infty \frac{Zr^5}{2a_0} e^{-\frac{Zr}{2a_0}} dr = \int_0^\infty \frac{Z}{2a_0} \left(\frac{2a_0}{Z}\right)^6 x^5 e^{-x}$$

$$= \left(\frac{2a_0}{Z}\right)^5 \int x^5 e^{-x} dx = 120 \left(\frac{2a_0}{Z}\right)^5 \; \lrcorner$$

$$= \pi \left(\frac{Z}{2a_0}\right)^4 \left(\frac{2a_0}{Z}\right)^5 (24-120)$$

$$= \frac{2a_0\pi}{Z} \cdot (-96) = -192 \frac{a_0 \pi}{Z}$$

7)



$$|L| = \sqrt{l(l+1)}\,\hbar$$

$$L_z = m\hbar \overset{max}{=} l\hbar$$

$$\cos\Theta = \frac{L_z}{L} = \frac{l}{\sqrt{l(l+1)}}$$

$l=1$: $\Theta = 45°$

$l=2$: $\Theta = 35{,}26°$

$l=3$: $\Theta = 30°$

8) Übergang von $3p \rightarrow 3s_{1/2}$

$3p_{1/2}$
$3p_{3/2}$
} Aufspaltung wegen Feinstruktur

$$E = E_n\left(1 - \frac{Z^2\alpha^2}{n}\left(\frac{3}{4n} - \frac{1}{j+1/2}\right)\right)$$

9) $^3D_{3,2,1}$ $l=2$, $s=1$, $j = 3,2,1$

$$\Delta E = (m_l + 2m_s)\mu_B B$$

$m_l = 2, \dots, -2$
$m_s = 1, \dots, -1$
} $m_l + 2m_s = 4, \dots, -4$

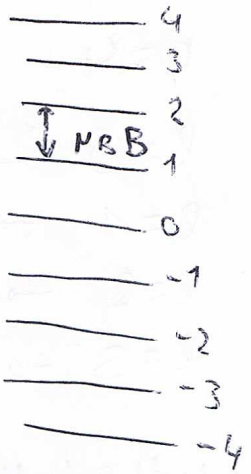
$\overline{j=3}$

$\overline{j=2}$

$\overline{j=1}$

$B=0$

} Keine Feinstruktur-Aufspaltung, da keine j-Kopplung $l=2, s=1$



10.) a ist korrekt

11.) a) Ni^{2+}: [Ar] $3d^1\ 4s^2$ (vgl. Besetzungsreihenfolge)

$l=2$ $l=1$ $l=0$ $l=-1$ $l=-2$

↑ _ _ _ _ _ (3d)

↑↓ (4s)

$s = 1/2$, $l = 2$ } $j = l - s$

$\Rightarrow {}^3D_{3/2}$

b) Sm^{2+}: [Xe] $6s^2\ 4f^4$

$l=3$ $l=2$ $l=1$ $l=0$

↑ ↑ ↑ ↑ _ _ _ (4f)

$s = 2$, $L = 6$ } $j = L - s$

$\Rightarrow {}^5I_4$

c) Gd^{3+}: [Xe] $6s^2\ 4f^5$

$l=3$ 2 1 0 -1

↑ ↑ ↑ ↑ ↑ _ _ (4f)

$s = 5/2$, $L = 5$ } $j = 5/2$

$\Rightarrow {}^6H_{5/2}$

12.) Multiplizität $2s+1$ ändert sich nicht

($\Delta s = 0$)