#11

8.21

$$E = \hbar\omega = \frac{hc}{\lambda}$$

$$\Delta E = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$$

$$= 1240 \text{ eV nm} \left(\frac{1}{766.41} - \frac{1}{769.90} \right) = \boxed{7.3 \times 10^{-3} \text{ eV}}$$

$$\Delta E = -\vec{\mu}_s \cdot \vec{B} = + \frac{e}{m} \hbar B$$

$$B = \frac{m \Delta E}{e\hbar} = \frac{2m}{e\hbar} \frac{\Delta E}{2}$$

$$= \frac{1}{5.7884 \times 10^{-5} \text{ eV/T}} \cdot \frac{7.3 \times 10^{-3} \text{ eV}}{2}$$

$$= \boxed{63.1 \text{ T}}$$

8.22

Hund's rules $\Rightarrow$

$^1S_0$

$^1D_2$

$^3P_2$

$^3P_1$

$^3P_0$

there are no $\Delta S = 0$ / $\Delta l = \pm 1$ transitions

8.30

anomalous Zeeman effect is due to both μ_l and μ_S

normal Zeeman effect is due to μ_l only

$\vec{S} = 0 \Rightarrow$ only normal Zeeman effect true for all levels (both ground and excited states)

an atom could exhibit both (if there are 2 optically active electrons $S = 0$ or $S = 1$ for example)

8.36

see fig 8.16

$^2S_{1/2}$ $g = 2$ (p 290)

$^2P_{1/2}$ $g = 2/3$ (p 290)

$\Delta E = \mu_B B_{ext} \, g \, m_j$

$^2S_{1/2}$ $\Delta E_1 = \pm 5.7884 \times 10^{-5} \; eV/T \cdot 0.5\,T \cdot 2 \cdot 1/2$

$= \pm 2.8942 \times 10^{-5}$ eV

$^2P_{1/2}$ $\Delta E_2 = \pm 5.7884 \times 10^{-5} \cdot 0.5 \cdot 2/3 \cdot 1/2$

$= \pm 9.6473 \times 10^{-6}$ eV

now $\Delta E_{short} = \Delta E_1 + \Delta E_2$

$\Delta E_{long} = -\Delta E_1 - \Delta E_2$

in both cases

$$\Delta E = \pm \Delta E_1 + \Delta E_2$$

$$= 3.85893 \times 10^{-5} \text{ eV}$$

$$E = \frac{hc}{\lambda} \qquad \frac{dE}{d\lambda} = -\frac{hc}{\lambda^2}$$

$$\Delta\lambda = \frac{\Delta E \lambda^2}{hc} = \frac{3.85893 \times 10^{-5} \text{ eV} \cdot (589.76)^2 \text{ nm}^2}{1239.8 \text{ eVnm}}$$

$$= 1.082 \times 10^{-2} \text{ nm}$$

difference is 2x this $= \boxed{2.16 \times 10^{-2} \text{ nm}}$

8.37

$$\Delta E = \mu_B B_{ext}\, g\, m_j$$

$^2P_{3/2} \Rightarrow m_j = \pm\frac{3}{2}, \pm 1/2$

$g = 4/3$ (p 290)

$$\Delta E = 5.7884\times10^{-5}\cdot 0.5 \cdot \frac{4}{3}\cdot\frac{1}{2}$$

$$= 1.929\times10^{-5}\ \text{eV}$$

splitting between states is 2x this

$$= \boxed{3.859\times10^{-5}\ \text{eV}}$$

8.39

$Sc^{(-)}$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

Al^- $1s^2 2s^2 2p^6 3s^2 3p^2$

$\ell = 0, 1, 2, 3$
s p d f

for Sc^-

$s_1 = 1/2$ $s_2 = 1/2$ $\Rightarrow$ $S = 0, 1$

$\ell_1 = 2$ $\ell_2 = 2$ $\Rightarrow$ $L = 4, 3, 2, 1, 0$

for $S = 1$, L must be odd $= 1, 3$ for an overall antisymmetric wave function (recall symmetry of space part is -1^L)

for $S = 0$, L must be even $= 0, 2, 4$

Hund's rules $\Rightarrow$ lowest energy for max S
max L
min J

$\Rightarrow$ $S = 1$ and $L = 3$

$\Rightarrow$ ${}^3F_{4,3,2}$

$\Rightarrow$ ${}^3F_2$ is the ground state for Al^-

$s_1 = 1/2 \quad s_2 = 1/2 \quad \Rightarrow \quad S = 0, 1$

$l_1 = 1 \quad l_2 = 1 \quad \Rightarrow \quad L = 2, 1, 0$

$\Rightarrow$ $S = 1$ and $L = 1$ (odd)

$\Rightarrow$ $^3P_{2,1,0}$

$\Rightarrow$ $^3P_0$ is the ground state