Assignment 7 Solutions

Q6: TR3 7.P.20

5d state in a magnetic field (no spin)
$\ell=2$ $m_\ell = 2, 1, 0, -1, -2$ // energy Δ for zeeman $= (\mu_B B) m_\ell$
Biggest splitting $(2)-(-2) = 4$ units of m_ℓ $U = 4(\mu_B B)$
$B = 1.2T$, $\mu_B = 5.7884 \times 10^{-5}$ eV/T $U = 0.00028$ eV

Q7: TR3 7.P.20

Same almost, for $\Delta m_\ell = 1$, $\Delta U = \mu_B B = \Delta \frac{hc}{\lambda} \sim \frac{hc}{\lambda^2} \Delta\lambda$

$B = \left(\frac{1240 \text{eVnm}}{(434.1\text{nm})^2}(0.07\text{nm})\right) / 5.7884 \times 10^{-5} \text{eV/T} = 8.0T$ (webassign 7.96T)

Q8: TR3 7.P.29

2P state of atomic Hydrogen. Angular momentum is 1 so $\ell = 1$.
n = 2 always, m_ℓ can be -1, 0 ,1 and m_s can be +1/2 or -1/2

Q9: TR3 7.P.34

Allowed transitions always need a change in angular momentum of one. If the transition is to a lower n, a photon is emitted. If it is to a lower n, a photon is absorbed. If no B field is present, you can use the Bohr formula for the energy of the transition. If it is in the same n, there is no energy difference, so no photon, in the simple model.

Q10: TR3 8.P.04

First excited state of Krypton: Ground state is a completely closed shell (like Ar or He). If I added an electron, it would be Rubidium which has the electron in the 5s state. So for Krypton, we are losing one electron from the 4p6 filled level and promoting it to the 5s: 4p5.5s1

Q11: TR3 8.P.07

This is the outer electron for Na, so the inner shells provide some shielding expect $E = -\frac{13.6}{n^2}$ but since the shielding is not perfect $E = -\frac{13.6}{n^2} Z_{eff}^2$

$$Z_{eff} = \sqrt{\left(\frac{E_{seen}}{-13.6}\right) n^2} = \sqrt{\frac{-5.14}{-13.6}(3)^2} = 1.84$$

Q12: TR3 8.P.30

We get the normal Zeeman effect in transitions where S=0. We get the anomalous Zeeman effect in transitions where S is not zero. In our simpler view of the transitions (the allowed ones in the book), an atom will never exhibit both anomalous and normal Zeeman.

Q13: TR3 8.P.37

Splitting of $^2P_{1/2}$ due to external field, must use $g = 0.67$ for $^2P_{1/2}$ (from book)

$$\Delta E = V = \mu_B B_{ext}\, g(\Delta m_j) = 5.7884\times10^{-5}\frac{eV}{T}(0.54T)(0.67)\,1$$

$$= 2.09\times10^{-5}\, eV$$

Q14: TR3 8.P.12

$S = 1,\ L = 5$: J can be $L+S$ to $|L-S|$
6 to 4, so 5 is possible too (3 combos)

possible combos of $S = 2S+1 = 3$

For $L = 5$: $^3H_4$ ← minimizes j — groundstate (3 ← 2S+1, H ← L)

other possible $^3H_5$, $^3H_6$

Q15: TR3 8.P.16

$^{2(S)+1}L_J$ Progression of L:SPDFGHI