1) \[ n \quad l \quad m_c \quad m_s \quad \text{#Sublevel} \quad \text{#Level} \]

\[
\begin{array}{cccccc}
1 & 0 & 0 & 0 & 1/2, 1/2, 1/2, -1/2 & 2 & 2 \\
2 & 0 & 0 & -1 & 0 & 1 & 6 & 8 \\
3 & 0 & 0 & 1 & 0 & 1 & 3 & 6 \\
& -2 & -1 & 0 & 1 & 10 & 18
\end{array}
\]

Note: \[ n = 1, 2, 3, \ldots \]
\[ l = 0, 1, 2, \ldots n-1, \quad l < n \]
\[ m_c = -l, -l+1, \ldots 0 \ldots l-1, l \]
\[ E_0 = 13.6 \text{eV} \]

2) \[ (n, l, m_n, m_s) \]
\[
\begin{array}{cccccc}
(1, 0, 0, 1/2) & -E_0 & 0 & 0 & \sqrt{3/4} & \frac{1}{2} \\
(1, 1, 1, 1/2) & \text{Not Possible} & l < n \\
(3, 0, 0, -1/2) & -E_0/4 & 0 & 0 & \sqrt{3/4} + t & -\frac{1}{2} + t \\
(2, 1, -1, -1/2) & -\frac{1}{4} E_0 & \sqrt{2} - t & -t & \sqrt{3/4} + t & -\frac{1}{2} + t
\end{array}
\]
2 cont. \( (n_l, m_l, m_s) \)

\[ E = -\frac{\hbar}{\alpha} \]

\[ L = \sqrt{l(l+1)} \]

\[ L_z = m_e h \]

\[ S = \frac{1}{2} \]

\[ \frac{1}{2} m_s \]

- \( (3,-1,0, \frac{1}{2}) \) Not Possible \( l \geq 0 \)
- \( (3,2,2, \frac{1}{2}) \) \(-\frac{1}{4} \hbar \)
- \( (3,2,1, 0) \) Not Possible \( S = \frac{1}{2} \)
- \( (2,0,1, -\frac{1}{2}) \) Not Possible \( |m_e| \leq l \)

3)

\[ (n, l, m_l, m_s) \]

\[ E = \frac{1}{4} \hbar \]

\[ L = \sqrt{l(l+1)} \]

\[ L_z = m_e h \]

\[ S = \frac{1}{2} \]

\[ \frac{1}{2} m_s \]

- \( (3,0,0, \frac{1}{2}) \)
- \( (3,0,0, -\frac{1}{2}) \)
- \( (3,2,0, \frac{1}{2}) \)
- \( (3,2,0, -\frac{1}{2}) \)
- \( (3,2,1, \frac{1}{2}) \)
- \( (3,2,1, -\frac{1}{2}) \)
- \( (3,2,-1, \frac{1}{2}) \)
- \( (3,2,-1, -\frac{1}{2}) \)

4) 3d

\( n = 3 \)

\[ l = 2 \]

\[ L = \sqrt{l(l+1)} \]

\[ L_z = m_e h \]

\[ L_z \text{max} = 2h \]

\[ \cos \theta = \frac{2}{\sqrt{6}} \]

\[ \theta = 35^\circ \]
5) Allowed Transitions \( \Delta L = \pm 1 \)
\[ \Delta m_L = 0, \pm 1 \]
\[
(5, 2, 1, \frac{1}{2}) \rightarrow (5, 2, 1, -\frac{1}{2}) \quad \text{Forbidden, } \Delta L = 0
\]
\[
(4, 3, 0, \frac{1}{2}) \rightarrow (4, 2, 1, -\frac{1}{2}) \quad \text{Allowed}
\]
However, with what we know So far
They are degenerate States. So \( \Delta E = 0 \)
\[
(5, 2, -2, -\frac{1}{2}) \rightarrow (1, 0, 0, \frac{1}{2}) \quad \text{Forbidden, } \Delta L = 2
\]
\[
(2, 1, 1, \frac{1}{2}) \rightarrow (4, 2, 1, \frac{1}{2}) \quad \text{Allowed}
\]
\[
\Delta E = -\frac{\hbar^2}{4} - \frac{\hbar^2}{2} = -\hbar C (\frac{1}{4} - \frac{1}{16}) = \frac{3}{16} \hbar C
\]
The Photon is Absorbed because Final State has More Energy than Initial State

6) Allowed Transitions From \( n = 4 \) \( \rightarrow \) \( n = 3 \)
\[
\begin{align*}
 n = 4 & \quad l = 0, 1, 2, 3 & \quad S, P, D, F \\
 n = 3 & \quad l = 0, 1, 2 & \quad S, P, D
\end{align*}
\]
\[
\begin{align*}
 4s & \rightarrow 3p \\
 4p & \rightarrow 3s \\
 4p & \rightarrow 3d \\
 4d & \rightarrow 3p \\
 4f & \rightarrow 3d
\end{align*}
\]

7) Atomic State: a Unique Set of quantum Numbers represents a wavefunction
Atomic Level: a Collection of States with the Same Energy.
Spectral Line: Emitted Light with a given Frequency \( (\lambda, \text{Energy}) \). Light Given off by a Transition Between Levels
9) Spin-Orbit Coupling: The electron has a magnetic moment. If this magnetic moment is put into a magnetic field it can have 2 possible energies depending on whether it is aligned with the field or not. For $l \neq 0$ the electron goes around the nucleus. From the electron's viewpoint, the charge nucleus is going around the electron. The circling nucleus causes a magnetic field at the electron and splitting the level into 2 levels.

Don't answer the second part.

11) The nucleus has a magnetic moment which causes a small magnetic field at the electron and splits the level into different energy
12) For multi-electron atoms, screening causes low l states to have lower energy than the high l states.

Look at the radial wavefunctions. The l=0 electrons have a pretty large chance of being right next to the nucleus where they are inside of all the other electrons and they feel the full nuclear charge. This pulls their energy down.

The high l electrons tend to sit on the outside of the atom where they are attracted to the nucleus but are repelled by the other electrons so their energy is higher.