1. Verify the relation:

\[ \langle b || \nabla || a \rangle = \langle l_b || C_l || l_a \rangle \left\{ \begin{array}{l} \int_0^\infty dr P_b \left( \frac{d}{dr} + \frac{l_a}{r} \right) P_a, \quad \text{for} \ l_b = l_a - 1, \\ \int_0^\infty dr P_b \left( \frac{d}{dr} - \frac{l_a+1}{r} \right) P_a, \quad \text{for} \ l_b = l_a + 1. \end{array} \right. \]

Hint: Use vector spherical harmonics at the first step.

2. Verify

\[ \sum_n \tilde{f}_{ks\to np} = 1 \]

and

\[ \sum_n \tilde{f}_{kl\to nt-1} = -\frac{l(2l-1)}{3(2l+1)}, \]
\[ \sum_n \tilde{f}_{kl\to nt+1} = \frac{(l+1)(2l+3)}{3(2l+1)}. \]

3. Determine the lifetime of the \( 3p_3/2 \) excited state in Al. Hint: This state decays to the ground state by an M1 transition. The transition energy is found in the spectroscopic tables.