3. (W.12.5) Two are allowed and two are not.

It can be done in 1st order but it requires two quark generation changing vertices, which will make the decay rate smaller.

It can occur via 1st order W exchange but it requires 2 vertices that have quark generation changes, so the decay rate will be smaller.

$m \cdot D^0 \rightarrow K^+ + \pi^- + \pi^0 + \pi^0$
\[ d\bar{s} \kappa \rightarrow \pi^+ + e^- + \nu_e \quad u \bar{d} \]

Cannot go to \( u \bar{d} \) in 1\textsuperscript{st} order. \( \Rightarrow \) forbidden in 1\textsuperscript{st} order.

\[ 4 (\nu_{17.6}) \]

<table>
<thead>
<tr>
<th>Decay</th>
<th>( Q ) (MeV)</th>
<th>( T_{\text{MAX}} )</th>
<th>( W / T_{\text{MAX}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Lambda \rightarrow N + e^+ + \nu_e )</td>
<td>1.81</td>
<td>( \sim 1.81 \text{ MeV} )</td>
<td>( 5 \times 10^{-3} \times \left(1.81\right)^5 = 2.6 \times 10^{-4} )</td>
</tr>
<tr>
<td>( \Sigma^+ \rightarrow N + e^+ + \nu_e )</td>
<td>73</td>
<td>( \sim 75 \text{ MeV} )</td>
<td>( 2.53 \times 10^{-3} \times \left(75\right)^5 = 1.2 \times 10^{-4} )</td>
</tr>
<tr>
<td>( \pi^+ \rightarrow \mu^+ + e^+ + \nu_e )</td>
<td>4.085</td>
<td>( \sim 4.083 )</td>
<td>( \frac{1.39}{8} \times \left(4.083\right)^5 = 3.4 \times 10^{-4} )</td>
</tr>
<tr>
<td>( \mu \rightarrow \mu^+ + e^- + \nu_e )</td>
<td>0.782</td>
<td>( \sim 0.782 )</td>
<td>( 1.14 \times 10^{-2} \times \left(0.782\right)^5 = 3.25 \times 10^{-7} )</td>
</tr>
</tbody>
</table>

\[ Q = m_p c^2 - m_e c^2 - m_\mu c^2 \]

\( T_{\text{MAX}} \) is the maximum energy of the decay + daughter particles. The usual correction is \( \frac{1}{2} m_{\text{daughter}} T_{\text{MAX}}^2 \) where \( Q \) is \( \mathcal{O}(\%\) by 8 orders of magnitude.

\[ 5 (\nu_{14.8}) \]

\[ 0^+ \bar{d} \bar{c} \quad 0^+ \bar{d} \bar{c} \]

\[ \kappa \rightarrow \kappa^* \rightarrow d \bar{d} \quad \bar{d} \rightarrow \pi^0, \nu, \bar{\nu} \]

\[ q_T = \frac{u \bar{d}}{u_3} \]
by the unitarity of the CKM matrix, the diagrams on the L.H.S and RHS can be combined by assuming a 100% branching C \rightarrow g

Similarly, the hadronic decay can be approximated by considering only the non-lepton channel with 100% branching.

\[ \frac{1}{\tau_d} = 5 \cdot \left( \frac{m_D}{m_L} \right)^5 = 5 \cdot \left( \frac{1870 \text{ MeV}}{105 \text{ MeV}} \right)^5 \approx 9 \times 10^6 \]

so we have, effectively, 1 lepton decay channels and 3 quark channels, giving a total of 5 decay channels.

\[ \frac{1}{\tau_u} = 5 \left( \frac{m_D - m_X}{m_D} \right)^5 \approx 5 \left( \frac{1375}{805} \right)^5 = 1.93 \times 10^6 \]

Taking \( m_L \) into account, we find the lifetime estimate:

\[ \frac{1}{\tau} = 4.55 \times 10^{-5} \text{ s}^{-1} \cdot 1.93 \times 10^6 = 8.76 \times 10^{-1} \text{ s}^{-1} \]

\[ \tau \approx 1.1 \times 10^{-12} \text{ s} \]