Q 1:

In the shell model, we have a structure that is analogous to that of the atomic structure. The ground state is predicted by knowing the the nucleons on the "valence" band. For a ^{13}C, the last nucleon, a neutron, occupies a $1p_{\frac{1}{2}}$, and since it has even protons and odd neutrons, it has a parity $P = (-1)^{\ell} = -1 \implies \frac{1}{2}^{-}$ ground state. The first nucleon excitation will be a neutron going from $1p_{\frac{1}{2}}$ into $2s_{\frac{1}{2}} \implies \frac{1}{2}^{+}$. The next excitation will be a neutron going from $1p_{\frac{3}{2}}$ into $1p_{\frac{1}{2}}$ leaving the unpaired electron level at $1p_{\frac{3}{2}} \implies \frac{3}{2}^{-}$. Finally, the last excitation will be a a neutron going from $1p_{\frac{1}{2}}$ into $1d_{\frac{5}{2}} \implies \frac{5}{2}^{+}$.

Q 2:

Here, I plotted the moment of inertia values for each energy of each band. Then, I plotted the ratio of two successive moments of inertia for both bands:

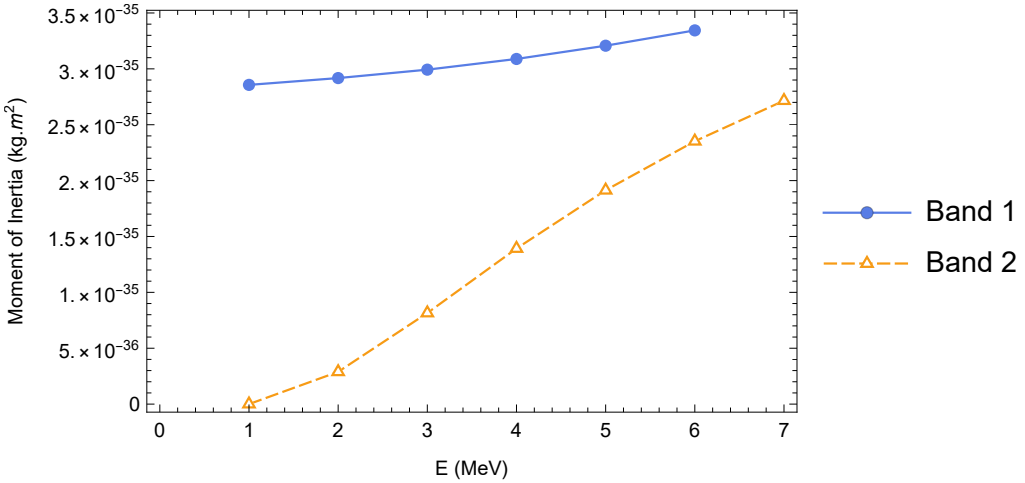

Figure 1: For Band 1, the value of the moment of inertia is almost constant, however, for Band 2, the value is not but it seems that it reaches the same value eventually.

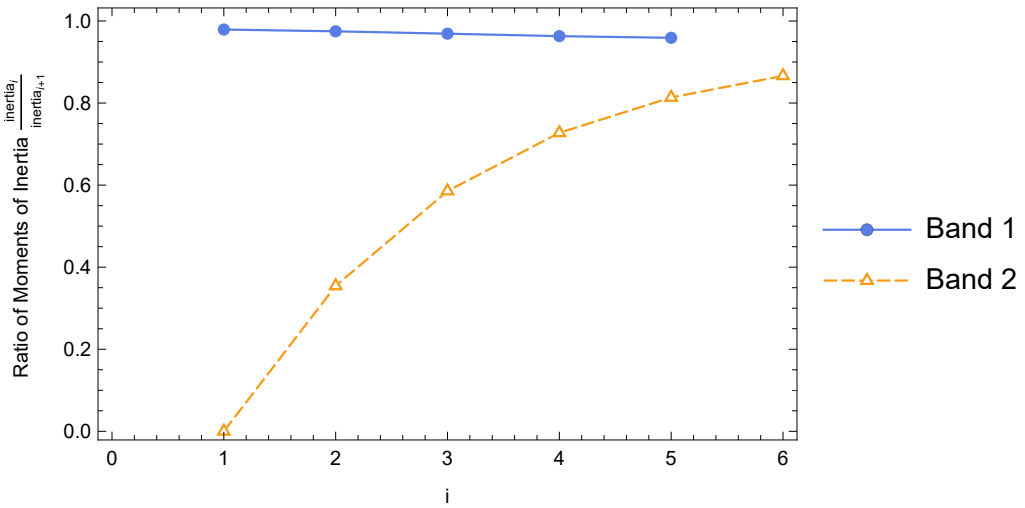

Figure 2: For Band 1, the ratio is constant, however, for Band 2, the ratio is not but it seems that it reaches 1 eventually.