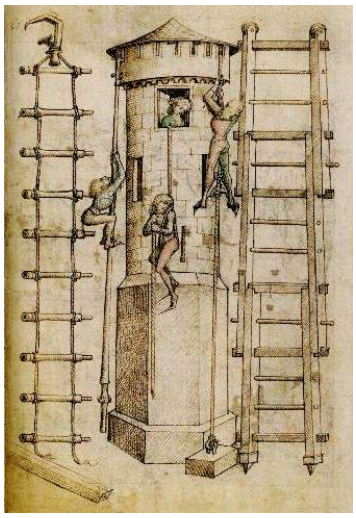
6. This question is about anammox and ladderanes

Anammox is an abbreviation for **an**aerobic **amm**onium **ox**idation. Despite being a crucial part of the nitrogen cycle, the bacteria responsible for this process were only identified as recently as 1999. In the membranes of these bacteria an unusual class of lipids were found. These lipids contained several fused cyclobutane rings. Such molecules are called ladderanes due to their resemblance to the rungs of a ladder.



The mechanism of ammonium oxidation is believed to involve several different nitrogen-containing species:

- nitrogen gas
- the ammonium ion
- the nitrite ion (NO_2^-)
- hydrazine (NH_2NH_2)
- hydroxylamine (NH_2OH).

(a) **(i)** Give the oxidation state of the nitrogen atom in nitrogen gas and in the ammonium ion.

(ii) Give the oxidation state of the nitrogen atom in the nitrite ion (NO_2^-), hydrazine (NH_2NH_2), and hydroxylamine (NH_2OH).

The reaction takes place over three steps, all of which can be assumed to take place under acidic conditions.

(b) Using your oxidation states from part (a), write equations for the following steps in the cycle.

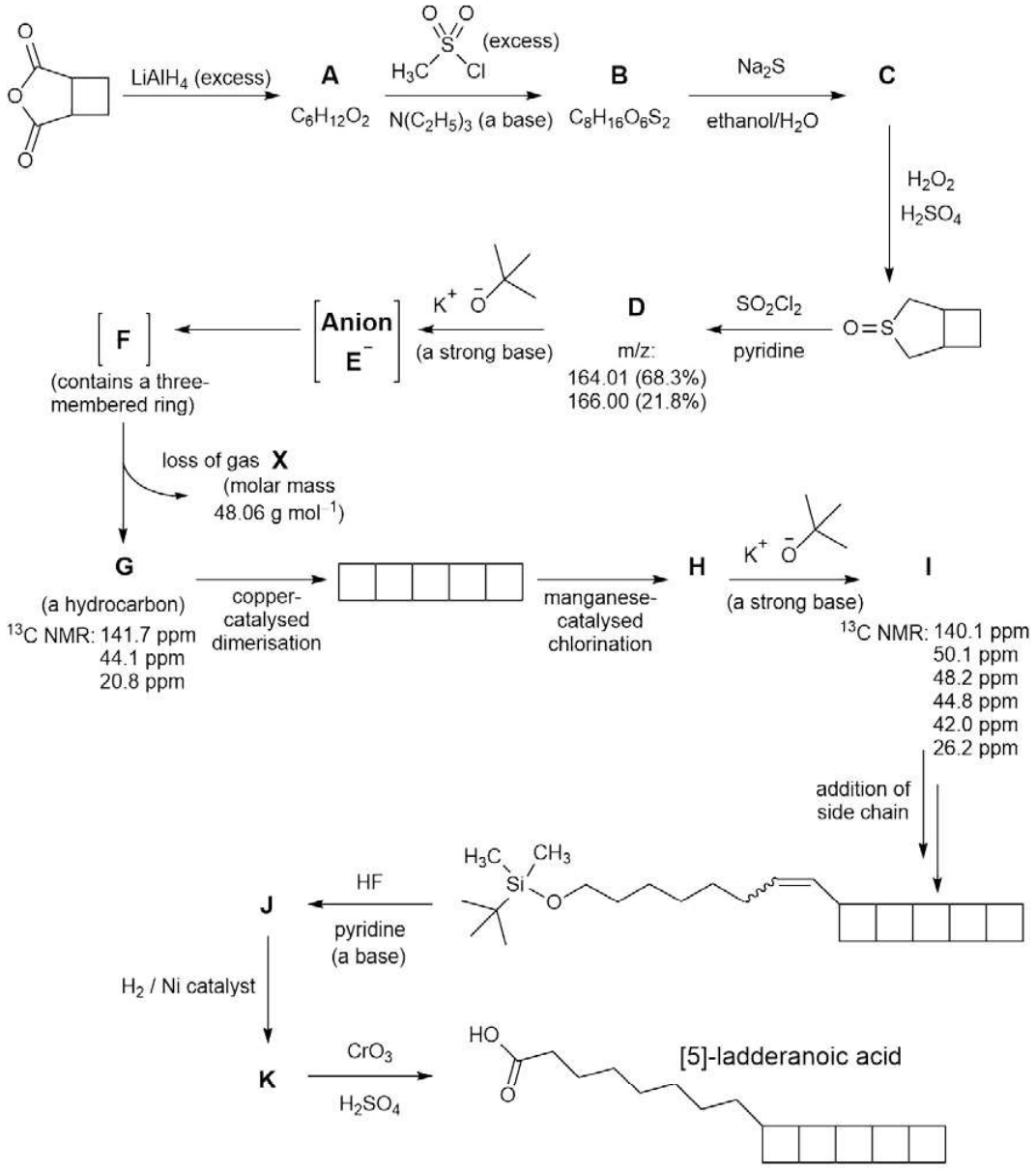
(i) Step 1: The half-equation for conversion of nitrite to hydroxylamine.

(ii) Step 2: The reaction of the ammonium ion and hydroxylamine to give hydrazine.

(iii) Step 3: The half equation for the conversion of hydrazine to nitrogen gas.

(c) Hence, write an overall reaction equation for the anammox process.

To further understand the lipids found in these bacteria, a research group synthesised [5]-ladderanoic acid – a key component of such lipids. The synthesis is shown below. Not all by-products are shown.



(d) Draw the structures of compounds **A** – **K** and by-product **X**. No stereochemistry is required in any structure.