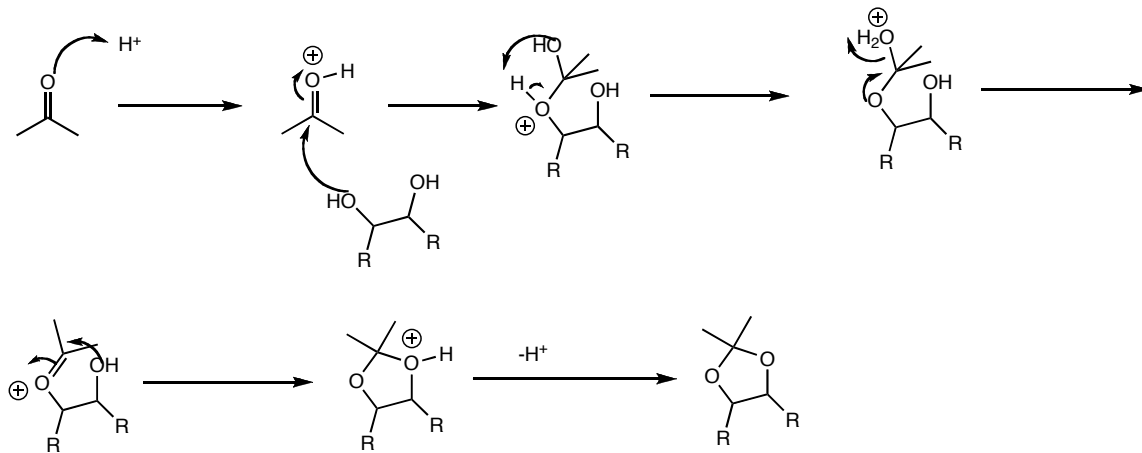
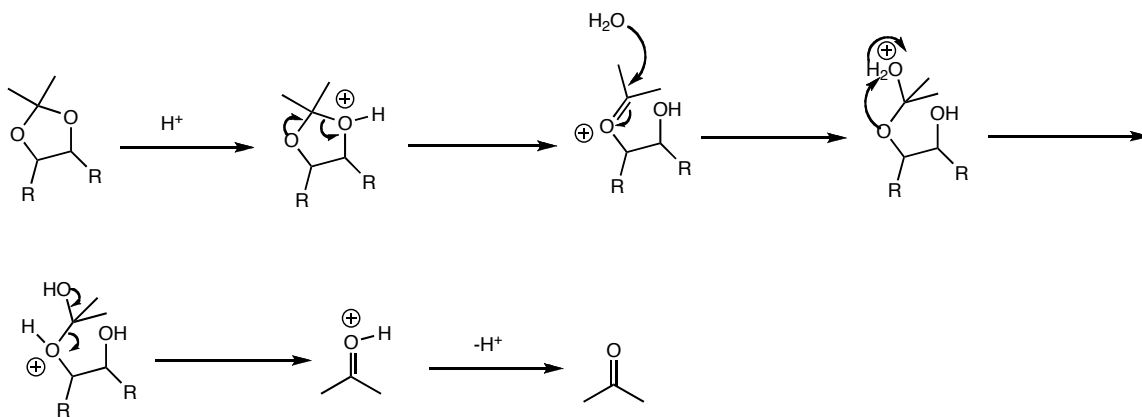


(a) Acetonide protecting groups were installed to protect the hydroxyl groups from oxidation in steps **3** to **4**.

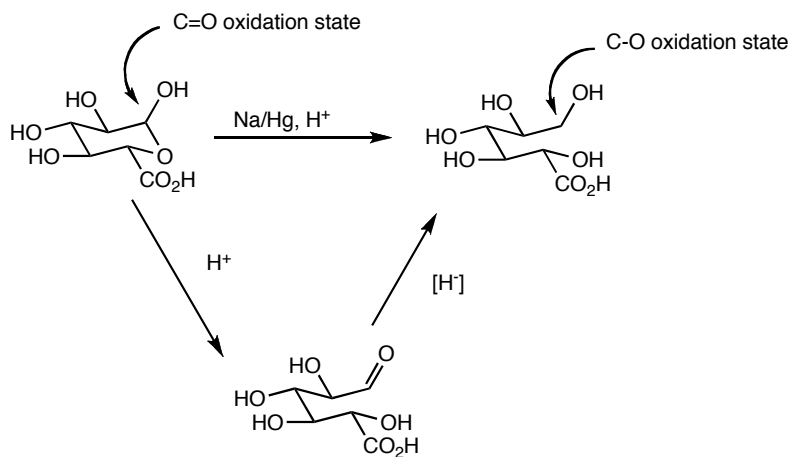
(b) Mechanism for protection:



(c) Mechanism for hydrolysis (deprotection)



(d) This reaction is an overall reduction. The carbon indicated below goes from an aldehyde oxidation state to an alcohol oxidation state. However, the hemiacetal itself cannot be reduced because it is not a carbonyl. Instead, in the presence of acid, the hemiacetal is in equilibrium with the alcohol/aldehyde, and it is this aldehyde that is reduced.



(e) The mechanism is the same as for formation of imines.

(f) The lactone carbonyl is added in the form of a cyanide. In the transformation from **9** into **1**, the nitrile is hydrolyzed to a carboxylic acid, which then cyclizes as the lactone.