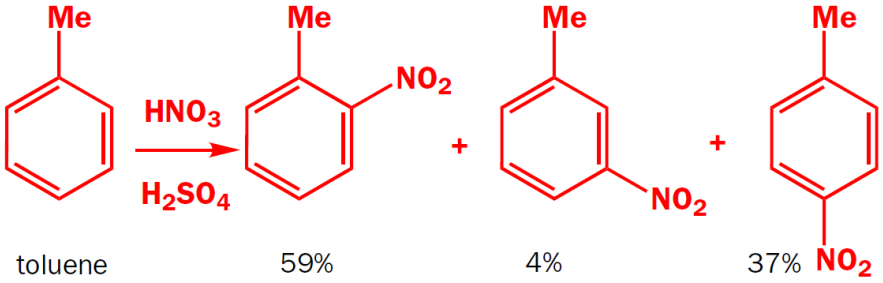
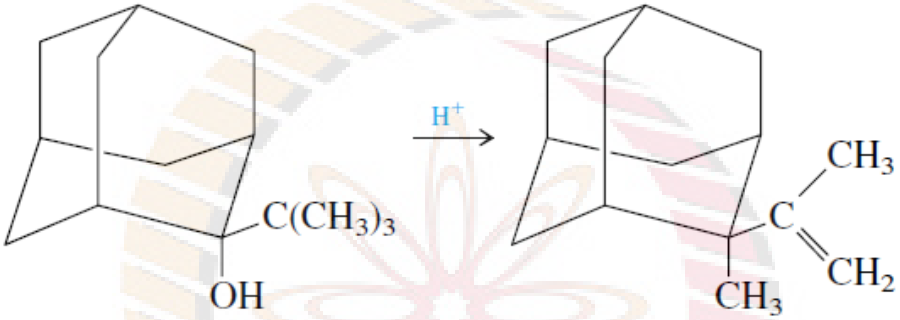
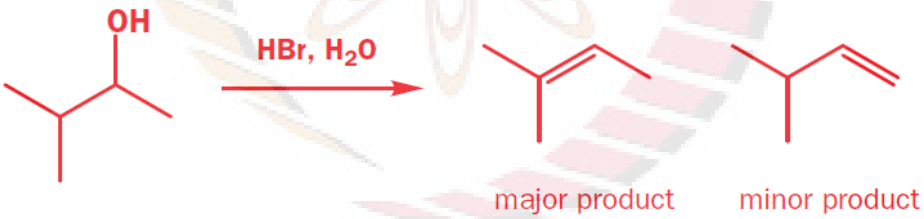
1. Nitration of toluene gives three products as shown below. Using this information, draw out an energy profile:



2. On standing in ^{17}O labelled water, both formaldehyde and its hydrate were found to have the labelled oxygen incorporated. Suggest a reasonable mechanism
3. For the following reaction, draw out a mechanism:

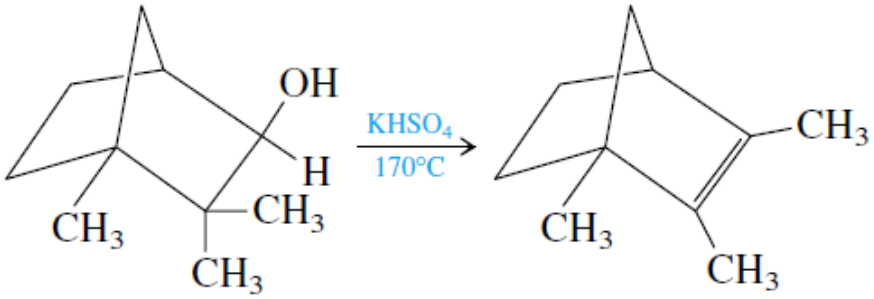


4. Draw out an energy profile that describes the following product distribution

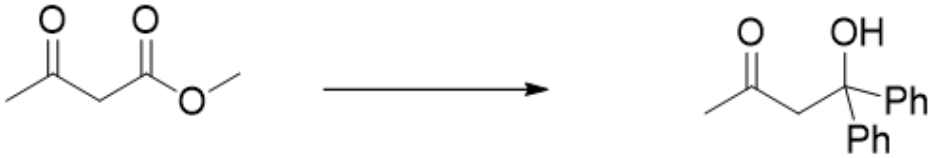


5. Reaction of benzaldehyde with 1,2-octanediol in benzene containing a small amount of p-toluenesulfonic acid yields almost equal quantities of two products in a combined yield of 94%. Both products have the molecular formula $C_{15}H_{22}O_2$. Suggest reasonable structures for these products.

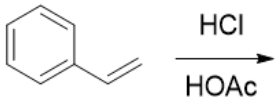
6. Draw out an arrow pushing mechanism for the following reaction:



7. Write out reagents for the following transformation:



8. When styrene was reacted with HCl in acetic acid, two products were isolated. Identify these products. Product B has an IR signal at 1740 cm^{-1}.

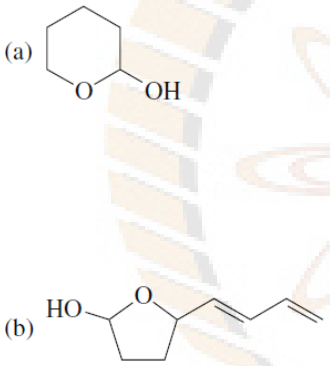


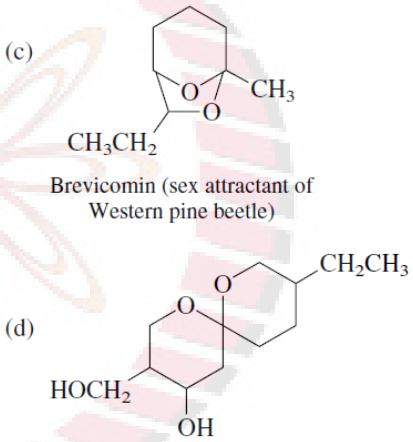
A + B

C_8H_9Cl, MW = 140.61 — 92% yield

$C_{10}H_{12}O_2$, MW = 164.20 — 8% yield

9. Deduce the structure of the open-chain form of each of the following acetals/hemiacetals.





Brevicomin (sex attractant of Western pine beetle)

10. The reaction of the following bromides with KOtBu was monitored by gas chromatography. The rates of reaction were monitored by following loss of the bromide. A significant difference in rate was observed. Provide a rationale for this large difference in rate.

Relative rate = 500 1