

## Week 3

# More Types of Reactions

### 3.1 Radical Chemistry

1/25:

- Reviews mass spectroscopy.
- Radical chemistry allows us to do some reactions that we cannot do in a two-electron manifold.
  - If we want to attach a nucleophile to the C2 position of propane, heat alone will not make the hydrogen on that position leave (hydrides are terrible leaving groups).
- Presents how easy (in terms of  $\Delta H$ ) it is to homolytically cleave various C–H bonds in alkanes.
- Radical stability is the same as carbocation stability.
  - In terms of decreasing stability,  
$$\text{benzylic} \approx \text{allylic} > \text{tertiary} > \text{secondary} > \text{primary} > \text{methyl}$$
  - Note that a benzylic or allylic *primary* radical is still more stable than a tertiary radical with no resonance stabilization.
- Three steps (initiation, propagation, and termination).
  - Initiation is either started by light ( $h\nu$ ) or heat ( $\Delta$ ).
- You can lose  $\text{CO}_2$  in a radical mechanism.

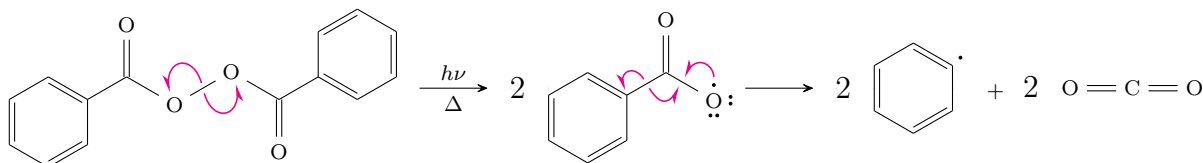


Figure 3.1: Losing  $\text{CO}_2$  in a radical mechanism.

- The second step is strongly favored by entropy ( $\Delta S$ ).
- Chlorination of alkanes.
  - If multiple types of C–H bonds are present, they will all be functionalized but in differing amounts.
    - The mechanism is sensitive both to the number of available hydrogens of each type, how sterically accessible hydrogens are, and (most importantly) radical stability.
  - You can also get polychlorinated products.

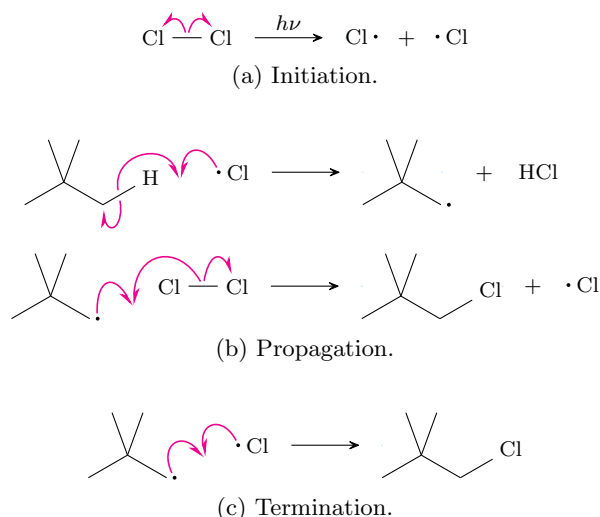


Figure 3.2: Chlorination of alkanes.

- Take-home message: If we use this, we only do so when all hydrogens are symmetric and we use excess starting material.
- Bromination of alkanes is basically the same.
  - One difference is that bromination is incredibly sensitive to radical stability, so whatever is the most stable radical will be the brominated one.
- Multistep synthesis example.
  - Propane to propane-1,2-diol.
  - Use radical bromination to put a bromine on C2, then  $\beta$ -elimination, then dihydroxylation.
- Allylic/benzylic halogenation.
- General form.
 
$$\text{---} \xrightarrow[h\nu]{\text{Br}_2} \text{---Br}$$
  - A possible side reaction is bromination of the alkene, but this requires a high temperature and low concentration.
  - The mechanism is entirely analogous to that of chlorination.
- HBr addition to alkenes.
  - The hydrohalogenation mechanism produces the Markovnikov product.
  - Morris Kharasch at UChicago in 1933 proposed that a radical mechanism produced the anti-Markovnikov product.
    - In particular, when run in the presence of air, it proceeds quickly even at low temperatures and with the help of an organic peroxide.
- Mechanism.
  - In hydrohalogenation, the hydrogen adds into the double bond to form the most stable carbocation.
  - In this mechanism, the bromine adds into the double bond to form the most stable radical.

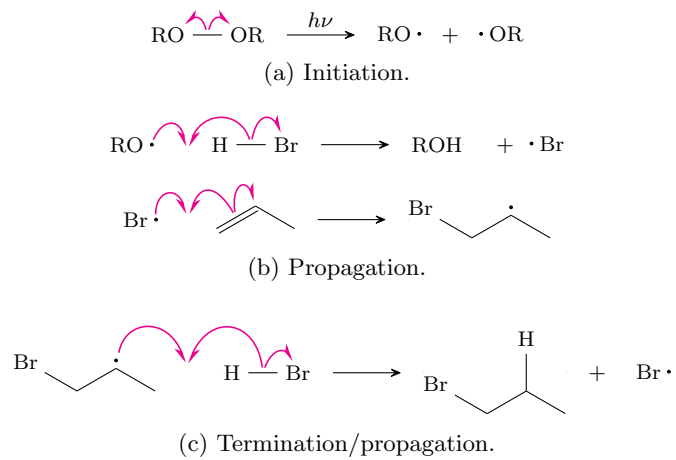


Figure 3.3: Radical hydrohalogenation.