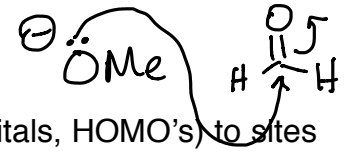
Lecture 4: Arrow-Pushing Mechanisms & FMO

TODAY:
- Arrow-pushing mechanisms
- Effects Governing Reactivity & Structure

ANNOUNCEMENTS:
- Problem Set 1 due now
- Do NOT look at Grossman's answer keys online until AFTER you turn in your problem sets. (Wrestling with the mechanisms is how you will learn them!)`

A 12-Step Program for Arrow Pushers

Adapted from Prof. K. A. Woerpel and Prof. C. J. Douglas

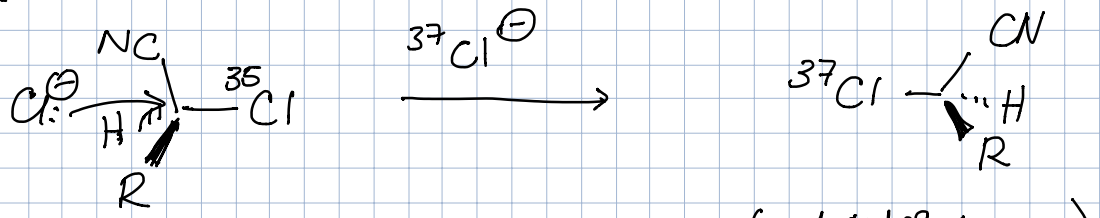


1. Electrons flow from sites of high electron density (filled orbitals, HOMO's) to sites of low electron density (unfilled orbitals, LUMO's). Arrows represent this electron flow.
2. Balance the equation. It really helps.
3. Don't violate the basic rules of physics.
    a. Conservation of mass and energy (a corollary to step 2)
    b. Conservation of charge (a more common error than you might think)
4. Three-Arrow Rule: Don't push more than 3 arrows at one time.
    a. Some rules were made to be broken — this one gets broken a fair amount, but do follow it as you are starting out.
5. Draw out all intermediates.
    a. Take your time here: a common mistake is to improperly draw an intermediate.
    b. Draw out the lone pairs and H's on reacting atoms.
    c. A 3-D depiction can be useful. Use models if necessary.
    d. Consider the reaction conditions when drawing intermediates: Do not draw carbocations under basic conditions or anionic leaving groups under acidic conditions.
6. Use your lone pairs.
7. All steps are, in principle, reversible.
8. Contemplate your options and carry each to its conclusion before discarding.
    a. It can be helpful to star (*) the intermediates where you made a choice to follow one pathway over another.
9. The correct mechanism gives the observed product.
10. Use connectivity to tell you how the puzzle fits together.
    a. A logical numbering system works wonders.
    b. "Principle of least action."
11. Always identify the nucleophiles and electrophiles at every step.
    a. At times it may be useful to substitute oxidants & reductants for nucleophiles and electrophiles.
12. Work backwards from the product to likely precursors.

Learning how to push arrows will help develop your 'chemical intuition.' These "12-steps" have been very helpful to me.

3 Universal Effects that Govern Chemical Reactions & Structure:

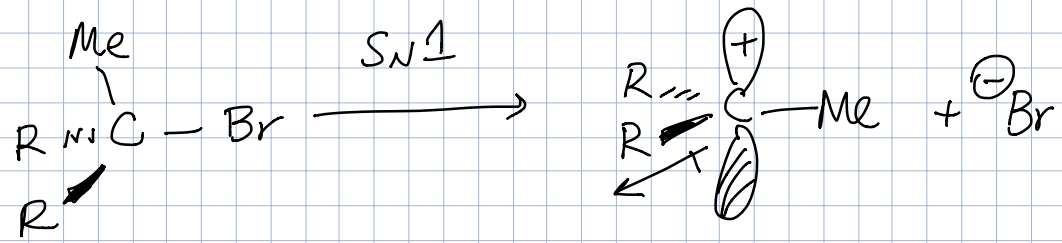
①



R	k (molecules/s · cm³)
CH_3	1.0×10^{-11}
tBu	1.6×10^{-12}

Steric Effect

②



Rate ↓ as R becomes more electroneg.

Electronic Effect

↳ Inductive Effect → σ-system

vs.

Resonance Effect → π-system

Through-space Electronic Effects

③ Stereoelectronic Effect

≡ Geometrical constraints placed upon ground & transition states by orbital overlap considerations.

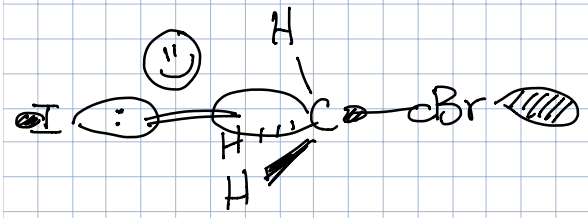
Fukui Postulate for Rxns:

"During the course of chem rxns, the interaction of the HOMO & LUMO is very important to stabilization of TS."

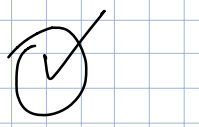
FMO ♡ Stereoelectronic Effects!

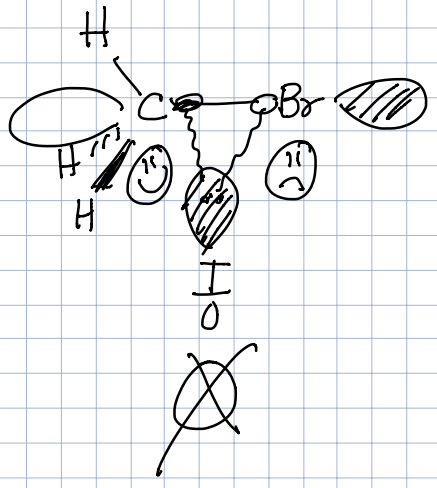
ex: S_N2 Rxn: Why Inversion?

$$I^{\ominus} \quad CH_3Br \longrightarrow I\text{-}CH_3 + Br^{\ominus}$$

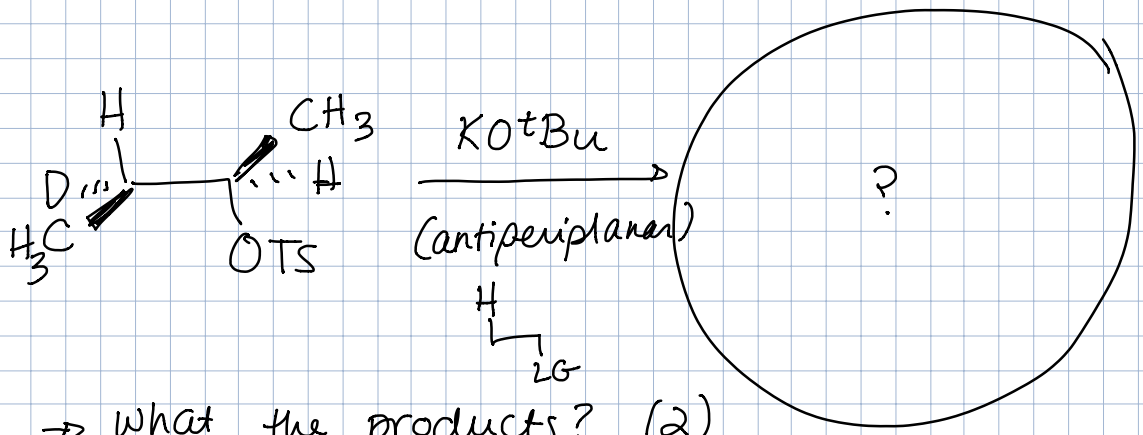


$lp_I \leftrightarrow \sigma^*_{C\text{-}Br}$





ex: E_2 Elimination



→ what the products? (2)

→ Why? → Stereoelectronic Argument please.

ex: Anomeric Effect. Why?