

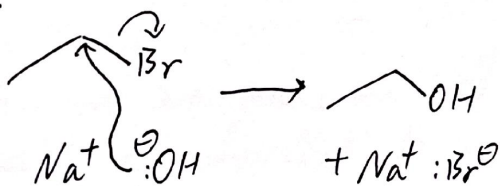
Revision: What should be taken into consideration when we need to write an organic mechanism?

In the advanced chemistry class taught by Dr. Yu, you have learned about there are 3 types of reaction: Free radical, Polar and pericyclic. Most of the organic reactions are polar reactions, so we are going to focus on them today.

The polar reaction is defined as interaction between electron-rich system and electron-lack system. Such interaction can cause break down and formation of bonds. We use curly arrows to express electron transfers.

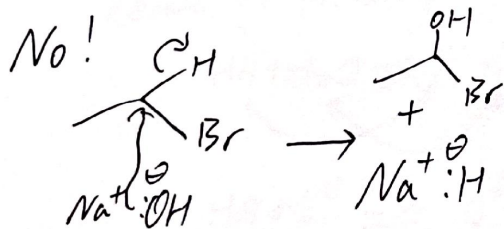
Electrons will move from electron-rich system to electron lack system. One of the most important way to deduce the ~~trans~~ transfer is electronegativity of an atom. For example:

Yes!



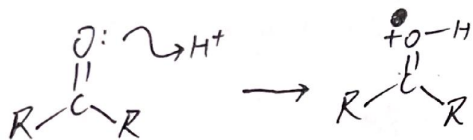
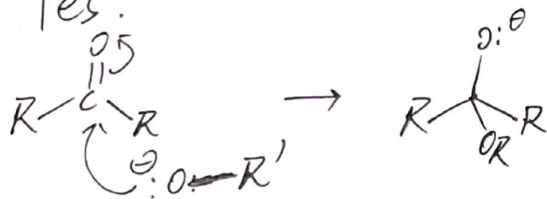
In bromoethane, electron will be attracted to bromine atom, so the carbon atom will be partially positively charged (δ^+), bromine atom will be partially negatively charged (δ^-).

Hence, when react with NaOH , negatively charged :OH^- will approach carbon to form C-O bond, then C-Br bond will be broken, lone pair transfer onto Br, bromide ion is formed.

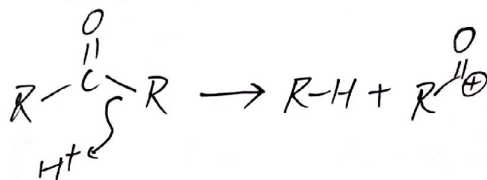
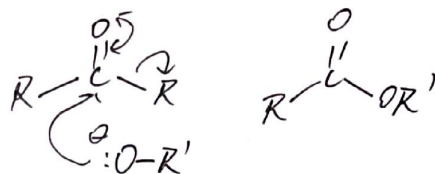


Now let's move on to carbonyl group. Electron pair in carbonyl group will be attracted to oxygen atom, which is more electronegative. Nucleophiles, those electron pair donors, will still tends to approach positively charged carbon to form a new bond. In addition, while reacting with Brønsted-Lowry acid, those proton donors, negatively charged oxygen will react with proton (H^+). Polarization happens. This will increase reactivity of it with ~~electrophiles~~ nucleophiles. Examples are given next page.

Yes!

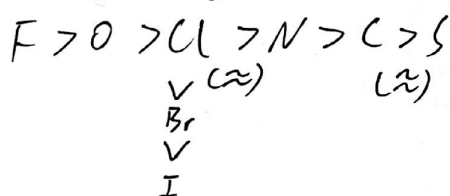


No!



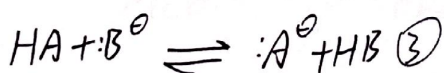
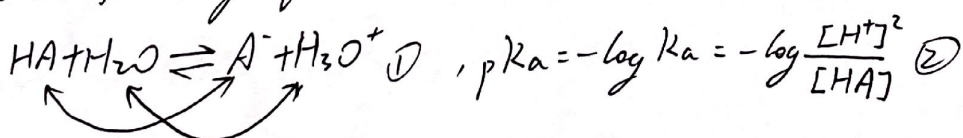
Conclusion: Charge is very important. Use charge to deduce where the reaction will happen.

Common electronegativity of atoms (highest to lowest):



Next, we are going to look at another important factor that should be considered. It is acidity and basicity.

Recall the following equations:



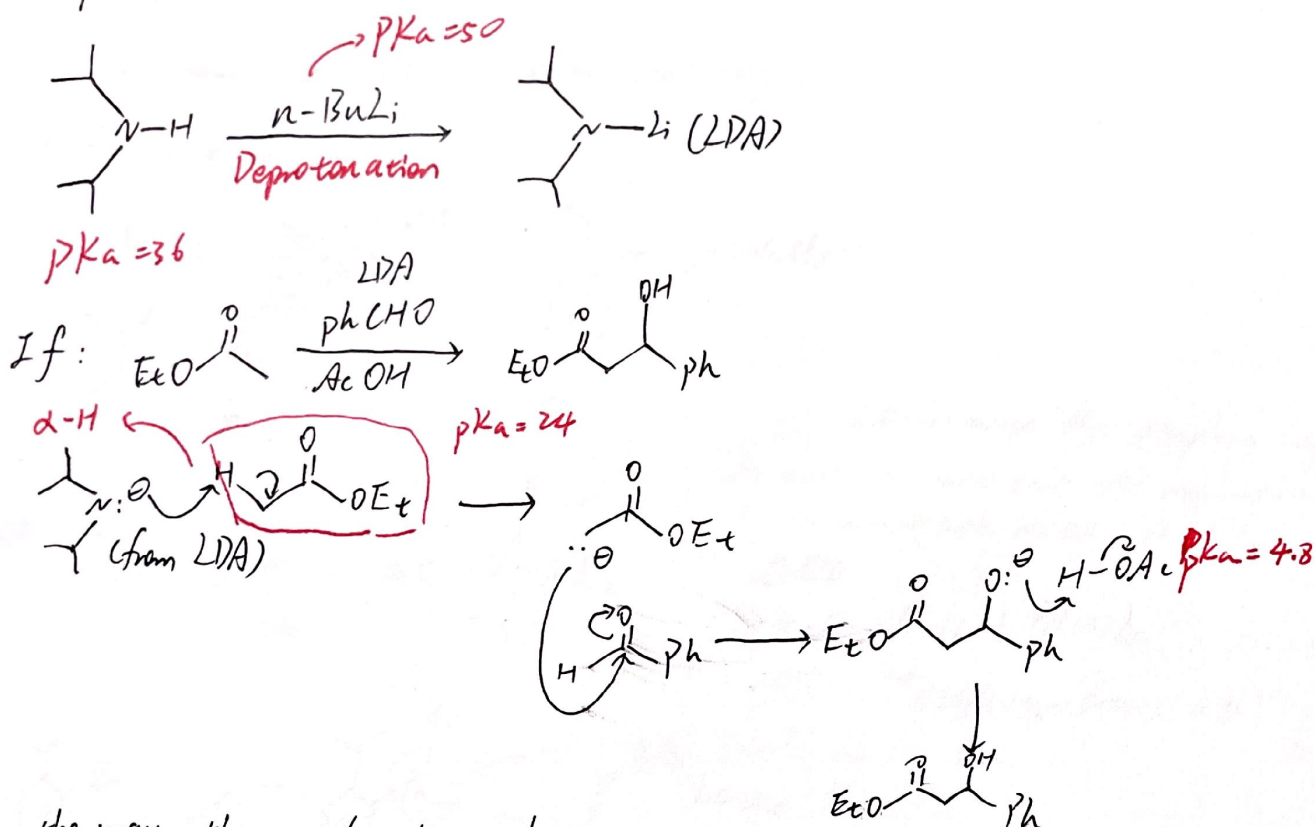
The K_{eq} of reaction 3 can be written as $K_{eq} = \frac{[\text{A}^-][\text{HB}]}{[\text{HA}][\text{B}^-]}$

$$\therefore \text{pK}_{eq} = -\log \left\{ \frac{[\text{A}^-][\text{HB}]}{[\text{HA}][\text{B}^-]} \right\} = \text{pK}_a(\text{HA}) - \text{pK}_a(\text{HB})$$

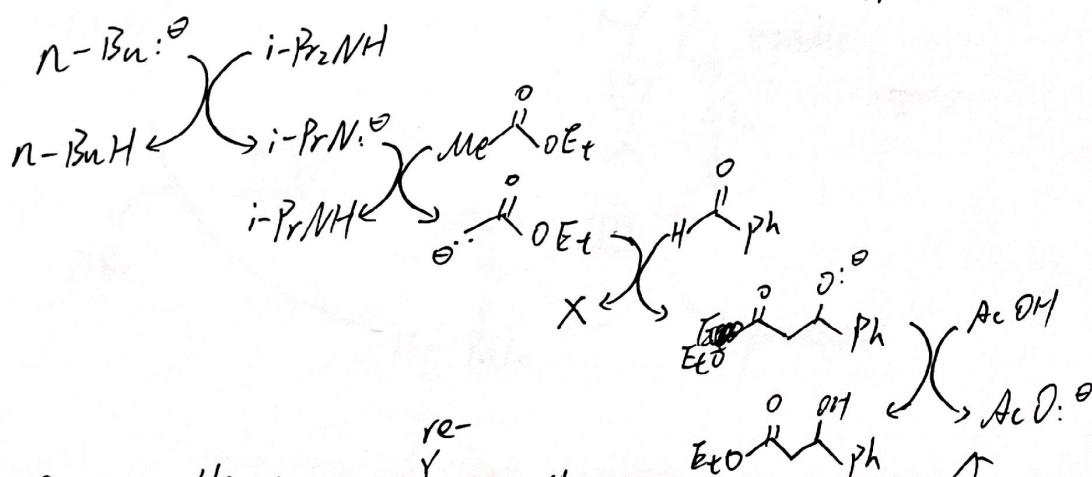
Hence, by calculating the difference between pK_a of acid and the base's conjugate acid, we can get start to write mechanisms. Remember that reactants with higher pK_a will continue to react to form intermediate with lower pK_a .

An example is given on next page.

Example:



By the way, the mechanism above can be written in another way. This writing method (standard) is more often used for coupling reactions. (See last page)



Study problem: try to write this mechanism in the way like this into a cycle like the example in the last page. You may ignore some by products if you want.

So now you have learnt some fundamental ways of writing organic mechanisms. However, this is just a start. Other factors such as spatial resistance are waiting for you to discover. Stay hungry, stay foolish. Good luck!

— Deng, W.

表② 酸度系数

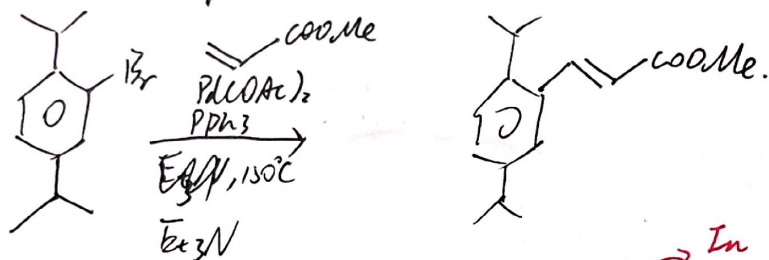
pKa	酸	酸根	pKa	酸	酸根
-10	$\text{HO}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	$\text{HO}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{O}^{\ominus}$	-1.4	$\overset{\ominus}{\text{O}}-\overset{\oplus}{\text{N}}(\text{OH})-\overset{\text{O}}{\parallel}$	$\overset{\ominus}{\text{O}}-\overset{\oplus}{\text{N}}(\text{O}^{\ominus})-\overset{\text{O}}{\parallel}$
-9	$\text{R}-\overset{\oplus}{\text{OH}}=\text{Cl}$	$\text{R}-\overset{\text{O}}{\parallel}=\text{Cl}$	-0.5	$\text{R}-\overset{\oplus}{\text{OH}}=\text{NH}_2$	$\text{R}-\overset{\text{O}}{\parallel}=\text{NH}_2$
-8	$\text{R}-\overset{\oplus}{\text{OH}}=\text{H}$	$\text{R}-\overset{\text{O}}{\parallel}=\text{H}$	0.5	$\text{F}_3\text{C}-\overset{\text{O}}{\parallel}=\text{OH}$	$\text{F}_3\text{C}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$
-7	$\text{R}-\overset{\oplus}{\text{OH}}=\text{R}$	$\text{R}-\overset{\text{O}}{\parallel}=\text{R}$	1.5	$\text{Ph}-\overset{\text{O}}{\parallel}=\text{OH}$	$\text{Ph}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$
-6.5	$\text{Ar}-\overset{\text{O}}{\parallel}=\text{OH}$	$\text{Ar}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$	2.0	$\text{HO}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$	$\text{O}^{\ominus}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$
-6.4	$\text{Ar}\overset{\oplus}{\text{O}}\text{H}_2$	ArOH	2.2	$\text{HO}-\overset{\text{O}}{\parallel}(\text{OH})-\text{OH}$	$\text{HO}-\overset{\text{O}}{\parallel}(\text{OH})-\text{O}^{\ominus}$
-6	$\text{Me}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$	$\text{Me}-\overset{\text{O}}{\parallel}=\text{OH}$	2.9	$\text{ClH}_2\text{C}-\overset{\text{O}}{\parallel}=\text{OH}$	$\text{ClH}_2\text{C}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$
-6	$\text{R}-\overset{\oplus}{\text{OH}}=\text{OH}$	$\text{R}-\overset{\text{O}}{\parallel}=\text{OH}$	4.2	$\text{Ph}-\overset{\text{O}}{\parallel}=\text{OH}$	$\text{Ph}-\overset{\text{O}}{\parallel}=\text{O}^{\ominus}$
-6	$\text{Ar}-\overset{\text{H}}{\overset{\oplus}{\text{O}}}-\text{R}$	$\text{Ar}-\text{O}-\text{R}$	4.8	$\text{Me}-\overset{\text{O}}{\parallel}=\text{OH}$	$\text{Me}-\overset{\text{O}}{\parallel}=\text{OH}$
-3.5	$\text{R}-\overset{\text{H}}{\overset{\oplus}{\text{O}}}-\text{R}$	$\text{R}-\text{O}-\text{R}$	6.4	$\text{HO}-\text{C}(=\text{O})-\text{OH}$	$\text{O}^{\ominus}-\text{C}(=\text{O})-\text{OH}$
-2.4	$\text{Et}\overset{\oplus}{\text{O}}\text{H}_2$	EtOH	10.0	PhOH	$\text{PhO}^{\ominus}$
-1.7	$\text{H}_3\overset{\oplus}{\text{O}}$	H_2O	11.6	$\text{HO}-\text{OH}$	$\text{HO}-\text{O}^{\ominus}$
-1.5	$\text{Ar}-\overset{\oplus}{\text{OH}}=\text{NH}_2$	$\text{Ar}-\overset{\text{O}}{\parallel}=\text{NH}_2$	12.2	$\text{Me}_2\text{C}=\text{NOH}$	$\text{Me}_2\text{C}=\text{NO}^{\ominus}$

Additional material.

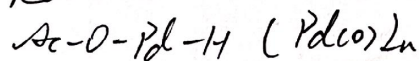
Coupling reactions (偶联反应)

Transition metal catalysed reactions (usually).

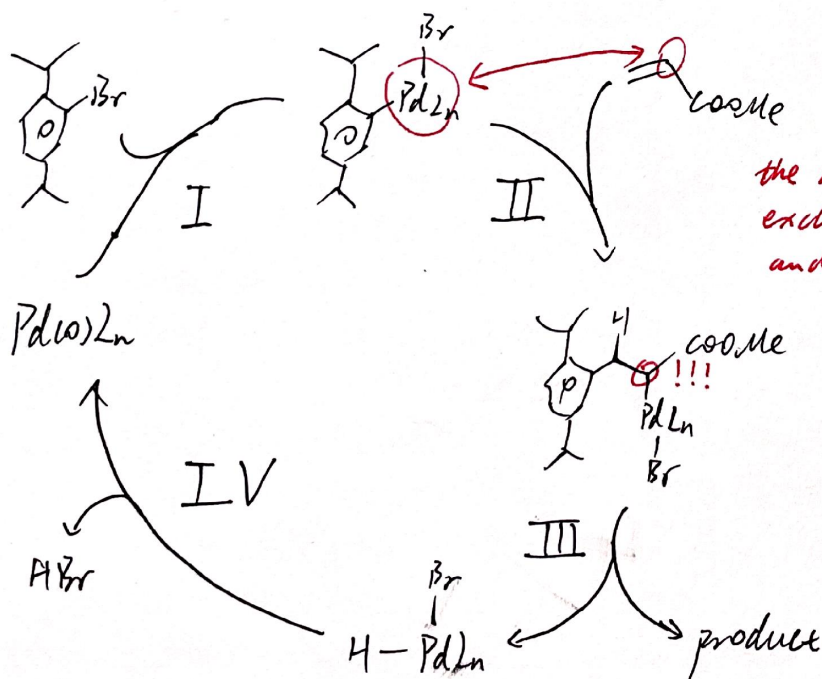
H Heck (As an example)



In order to make the coupling happen, we need to make sure the oxidation state of the transition metal is 0!



Oxidation state is 0!



In order to achieve that, the mechanism starts by a $\text{Oxidative addition}$, then a $\beta\text{-elimination}$, and finally, a $\text{reductive elimination}$.

Steps (Mechanism) of Heck coupling: I: Oxidative addition

II: Carbopalladation

III: $\beta\text{-elimination}$

IV: reductive elimination.

Due to some weird reason, most of the mechanisms of coupling reactions is written in this way, rather than typical electron pair transfer.