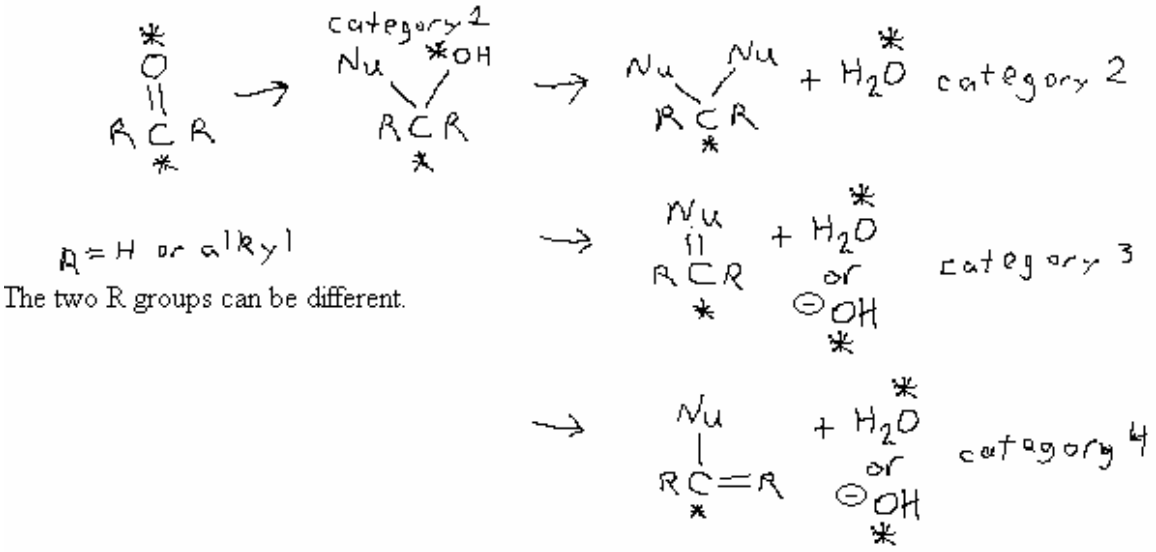

category 1: single nucleophilic attack
Nu is $LiAlH_4$, $NaBH_4$, RMgX, RLi, H_2O (acid or base cat.), ROH (base cat.)

Attack on carbonyl (read from top down) (basic conditions)
[starting material: aldehyde or ketone] Nu attacks carbonyl C, breaking π bond to carbonyl O. [product: alcohol (from H^- or R^-), diol (from H_2O), hemiacetal or hemiketal (from ROH)]

Formation of diols, hemiacetals, and hemiketals is reversible.

category 2: two nucleophilic attacks by separate atoms (acid catalyzed)
Nu is ROH

Attack on carbonyl (read from top down)	
[starting material: aldehyde or ketone] (Carbonyl O gains a H^+.) Nu attacks carbonyl C, breaking π bond to carbonyl O. (Nu loses a H^+.)* [intermediate: hemiacetal or hemiketal] ("Carbonyl" O gains a H^+.)* "Carbonyl" O leaves (as water). *Subsequently*, second Nu attacks "carbonyl" C. (Second Nu loses a H^+.) [product: acetal or ketal]	[product: aldehyde or ketone] (Carbonyl O loses a H^+.) "Nu" leaves "carbonyl" C, π bond to "carbonyl" O forms. (Second "Nu" gains a H^+.)* [intermediate: hemiacetal or hemiketal] ("Carbonyl" O loses a H^+.)* *Subsequently*, "carbonyl" O joins "carbonyl" C (as water). "Nu" leaves "carbonyl" C . ("Nu" gains a H^+.) [starting material: acetal or ketal]
	Revealing hidden carbonyl with H_3O^+ (BOTTOM UP)

*It is conventional to combine these two steps into a single proton transfer.

category 3: two nucleophilic attacks by the same atom (acid or base cat.)
Nu is RNH_2, where R is not necessarily a H or alkyl group
(Nu is: ammonia, if R is H; primary amine, if R is alkyl; hydroxylamine, if R is OH;
hydrazine, if R is NH_2 or derivative; semicarbazide, if R is $NHCONH_2$)

Attack on carbonyl (read from top down)	
[starting material: aldehyde or ketone] (Carbonyl O gains a H^+.) Nu attacks carbonyl C, breaking π bond to carbonyl O. (Nu loses a H^+.)* [intermediate: hemiaminal] ("Carbonyl" O gains a H^+.)* "Carbonyl" O leaves (as water), while… …Nu attacks "carbonyl" C a 2nd time, forming π bond. (Nu loses a H^+ a 2nd time.) [product: imine (from ammonia or primary amine); oxime (from hydroxylamine); hydrazone (from hydrazine or derivative) semicarbazone (from semicarbazide)]	[product: aldehyde or ketone] (Carbonyl O loses a H^+.) "Nu" leaves "carbonyl" C, π bond to "carbonyl" O forms. ("Nu" gains a H^+.)* [intermediate: hemiaminal] ("Carbonyl" O loses a H^+.)* …"carbonyl" O joins "carbonyl" C (as water). "Nu" loses π bond to "carbonyl" C, while… ("Nu" gains a H^+.) [starting material: imine, oxime, hydrazone, or semicarbazone]
	Revealing hidden carbonyl with H_3O^+ (BOTTOM UP)

Mechanism is shown for acid catalyst; you don't need to know the base-catalyzed mechanism.

category 3: two nucleophilic attacks by the same atom, Wittig reaction
Nu is C in $R_2C{=}PPh_3$ (phosphorus ylide) (R's are alkyls or hydrogens)

Attack on carbonyl (read from top down)
[starting material: aldehyde or ketone] Nu attacks carbonyl C, breaking pi bond to carbonyl O. [forms "betaine"] ("Carbonyl" O^- attacks P^+.) [intermediate: oxaphosphetane] "Carbonyl" O leaves by attacking P a 2nd time… ... *while* Nu attacks "carbonyl" C a 2nd time, forming π bond. [product: alkene]

*It is conventional to combine these two steps into a single proton transfer.

category 4: nucleophilic attack followed by elimination (acid or base cat.)
Nu is R_2NH (secondary amine)

Attack on carbonyl (read from top down)	
[starting material: aldehyde or ketone] (Carbonyl O gains a H^+.) Nu attacks carbonyl C, breaking π bond to carbonyl O. (Nu loses a H^+.)* [intermediate: hemiaminal] (“Carbonyl” O gains a H^+.)* “Carbonyl” O leaves (as water). *Then*… …“α” C loses a H^+, forming π bond to “carbonyl” C. [product: enamine]	[product: aldehyde or ketone] (Carbonyl O loses a H^+.) “Nu” leaves “carbonyl” C, π bond to “carbonyl” O forms. (“Nu” gains a H^+.)* [intermediate: hemiaminal] (“Carbonyl” O loses a H^+.)* … “carbonyl” O joins “carbonyl” C (as water). “α” C gains a H^+, losing π bond to “carbonyl” C. *Then.*.. [starting material: enamine]
	Revealing hidden carbonyl with H_3O^+ (BOTTOM UP)

Mechanism is shown for acid catalyst; you don’t need to know the base-catalyzed mechanism.

*It is conventional to combine these two steps into a single proton transfer.

category 1: single nucleophilic attack, ALDOL REACTION (base catalyzed, cold)
Nu is α-carbon in enolate

Attack on carbonyl (read from top down)	
[starting materials: two aldehydes or ketones] (Nu loses a H^+.) Nu attacks carbonyl C, breaking π bond to carbonyl O. ("Carbonyl" O gains a H^+.) [product: β-hydroxy aldehyde or ketone]	[products: two aldehydes or ketones] ("Nu" gains a H^+.) "Nu" leaves "carbonyl" C, π bond to "carbonyl" O forms. ("Carbonyl" O loses a H^+.) [starting material: β-hydroxy aldehyde or ketone]
	Revealing hidden carbonyl with HO^-, Δ (BOTTOM UP)

category 3: two nucleophilic attacks by the same atom, ALDOL CONDENSATION
(base cat., Δ)
Nu is α-carbon in enolate

Attack on carbonyl (read from top down)	
[starting materials: two aldehydes or ketones] ("Nu" loses a H^+.) Nu attacks carbonyl C, breaking π bond to carbonyl O. ("Carbonyl" O gains a H^+.)* [intermediate: β-hydroxy aldehyde or ketone] ("Nu" loses a H^+.)* "Carbonyl" O leaves (as hydroxide), while… …Nu attacks "carbonyl" C a 2nd time, forming π bond. [product: α,β-unsaturated aldehyde or ketone]	[products: two aldehydes or ketones] ("Nu" gains a H^+.) "Nu" leaves "carbonyl" C, π bond to "carbonyl" O forms. ("Carbonyl" O loses a H^+.)* [intermediate: β-hydroxy aldehyde or ketone] ("Nu" gains a H^+.)* …"carbonyl" O joins "carbonyl" C (as hydroxide). "Nu" loses π bond to "carbonyl" C, while... [starting material: α,β-unsaturated aldehyde or ketone]
	Revealing hidden carbonyl with HO^-, Δ (BOTTOM UP)

Label ("*") the carbonyl or hidden carbonyl C acting as electrophile, and keep it labeled.
Label ("*") the past or future carbonyl O, and keep it labeled.
Label ("α") the alpha-C acting as Nu, and keep it labeled.

*It is conventional to combine these two steps into a single proton transfer.