

## Carbonyls #2: So. Many. Carbonyl. MECHANISMS.

Yo, yo, yo—welcome back gang. Okay, I'm going to apologize in advance: You might be annoyed with/hate/want to hurt me after this worksheet. It's long, and it's basically mechanism, after mechanism, **after mechanism**. But I cannot stress how important it is to be automatic at and comfortable drawing these mechanisms, guys. Knowing the mechanisms, and the underlying principles of how they work, will make you better at Complete the Reaction and Synthesis problems moving forward.

Trust me on this one. One of the biggest reasons that I've seen kids crash and burn with this material is that they don't have solid fundamentals with these reactions, and then as more material is covered, they're lost and hopeless.

But that won't be us ☺. So do this worksheet 2, 3, 293877, however many times you need to until you are absolute **dynamite** at the mechanisms I have you doing here. So let's get on the next page and do some organic stuff with curved arrows, straight arrows, and dots.

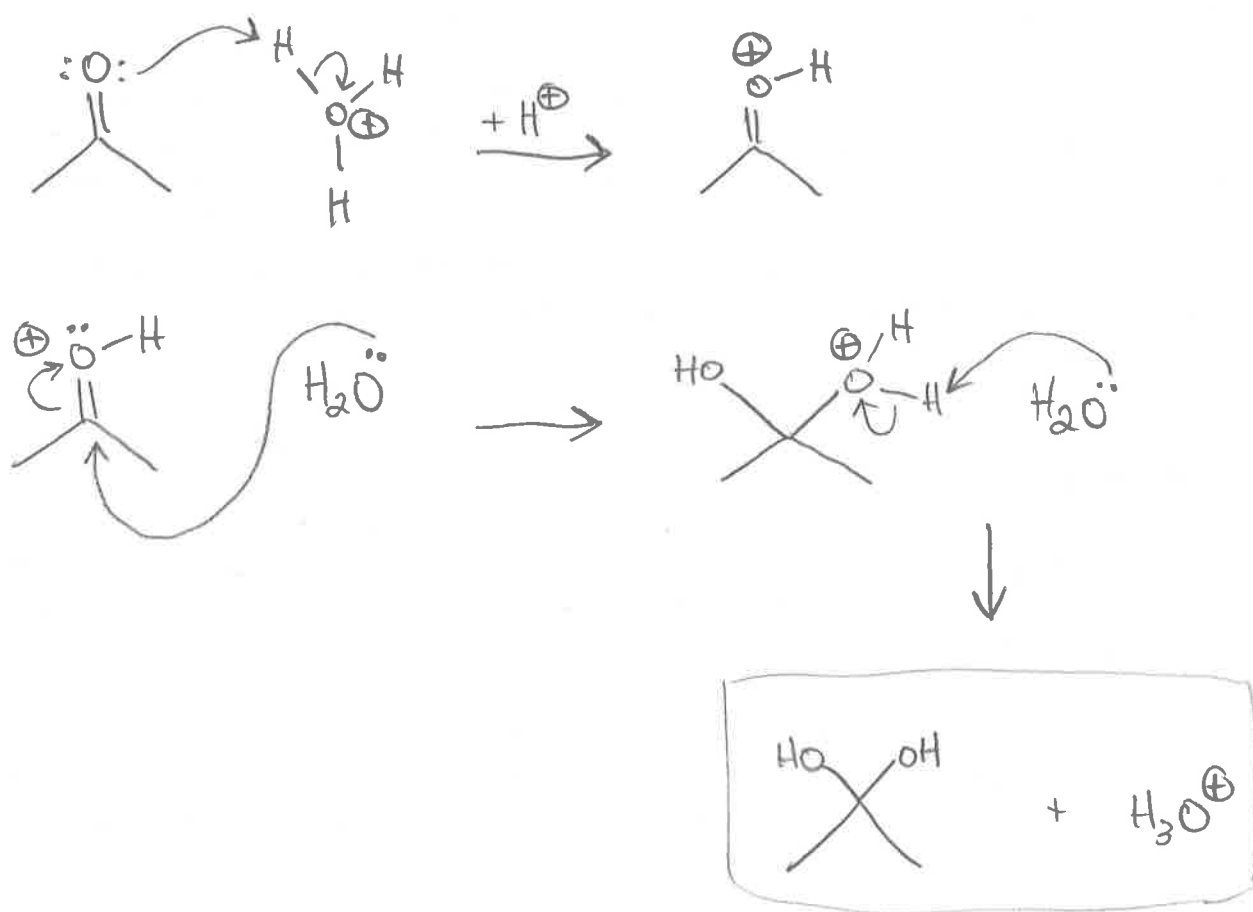
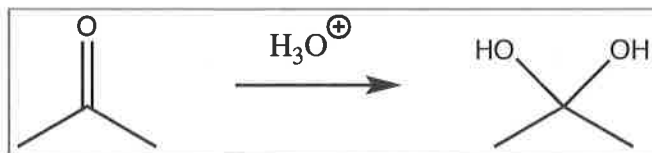
\*\*For each mechanism, I usually pick acetone (totally random, that's just what I do) as the starting molecule because it's small and simple, so it'll usually be acetone or a slightly bigger molecule than that.

### **Last 2 things:**

- Remember to protonate the carbonyl when starting off in an acidic environment. These reactions have some favorability issues, right? So protonating the carbonyl helps "activate" it and makes it more reactive.
- Remember, the groups we are trying to kick off get protonated (taking on positive formal charges) to make them better leaving groups, and the groups we add and want to stay on we deprotonate (to eliminate their positive formal charge).

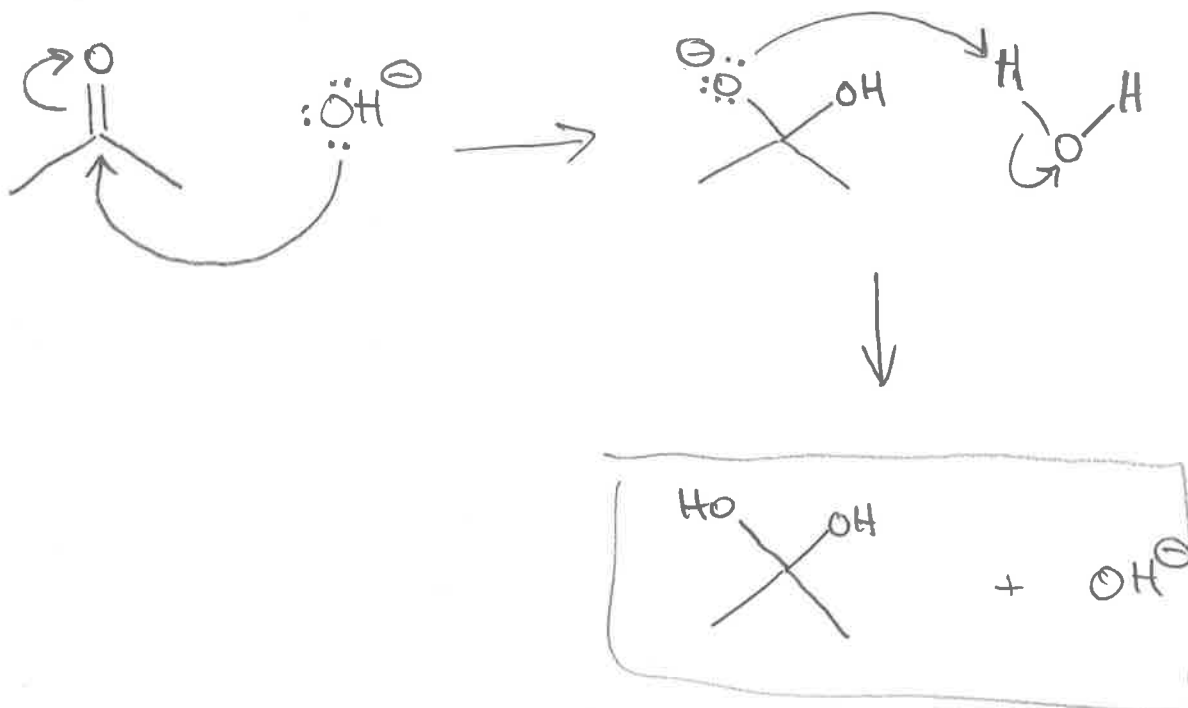
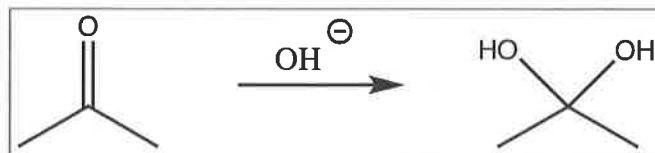
## 1.) Hydration of a Carbonyl.

a.) Draw the **forward** mechanism of the Hydration Reaction (in an **Acidic Environment**) pictured below:



1.) Hydration of a Carbonyl (continued)

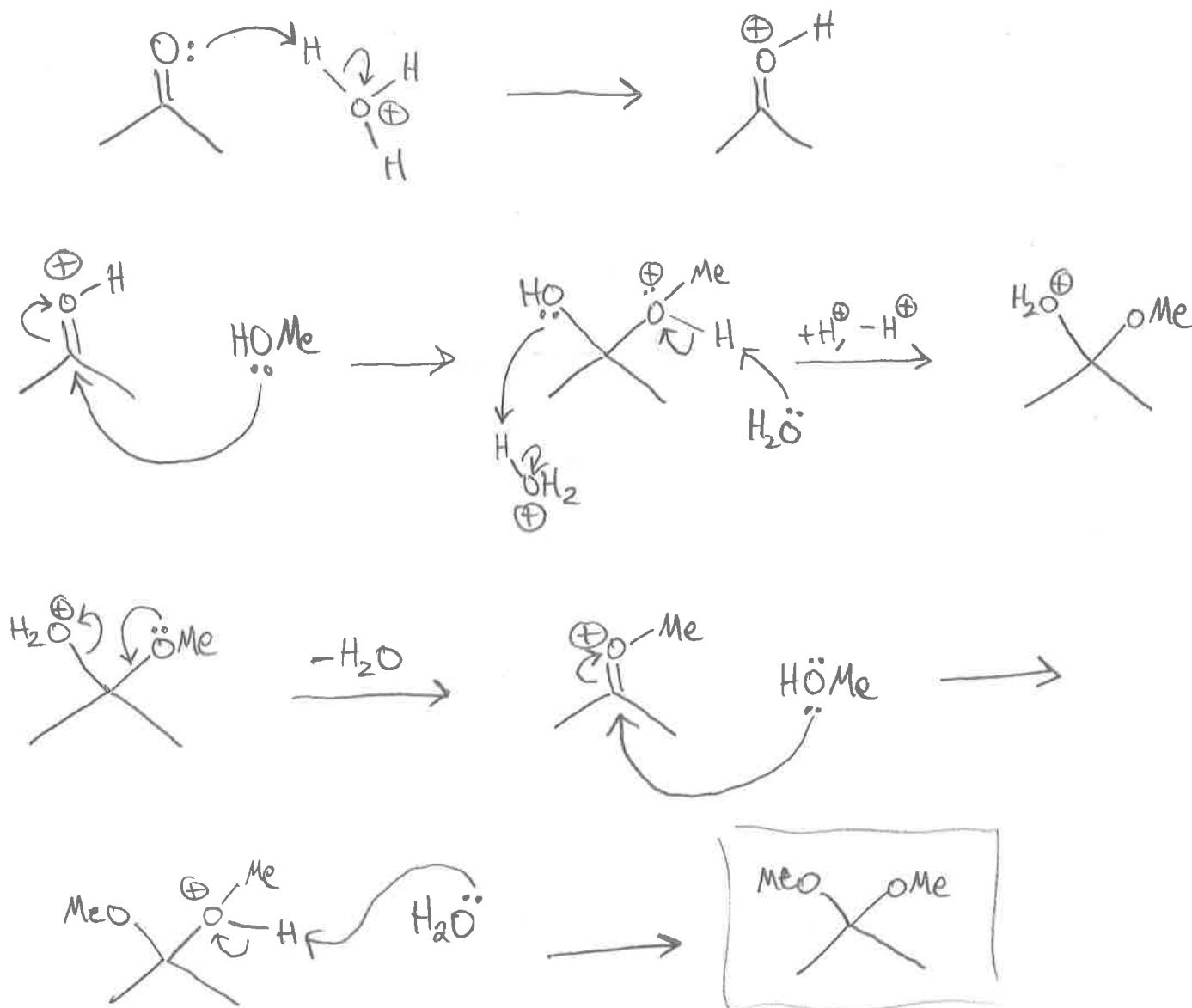
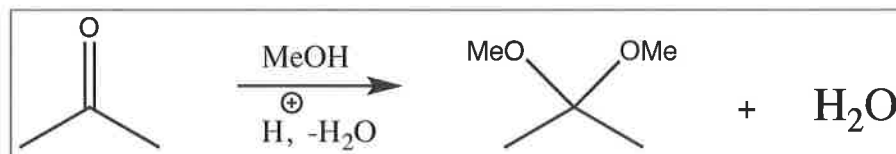
b.) Draw the **forward** mechanism of the Hydration Reaction (in a **Basic Environment**) pictured below:



## 2.) Acetal Formation

a.) Draw the **forward** mechanism of Acetal Formation (remember, this only happens in an **Acidic** Environment) pictured below:

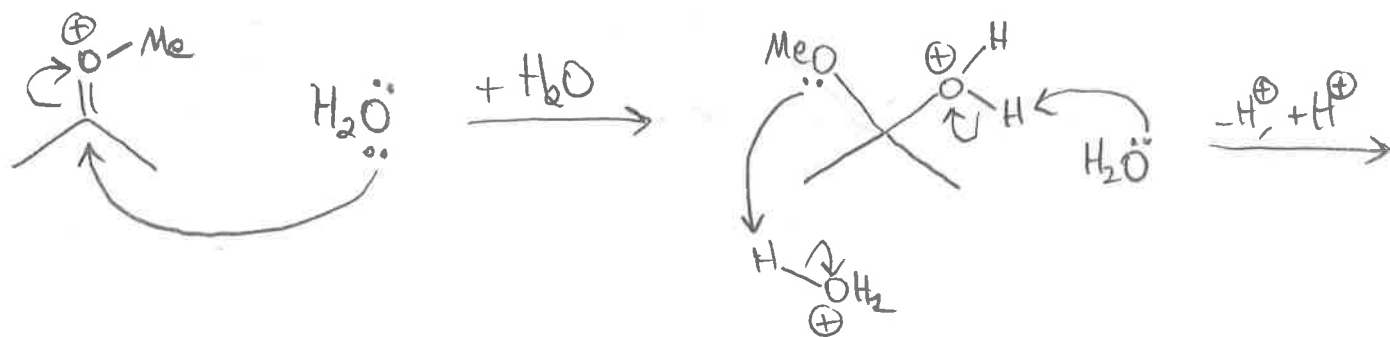
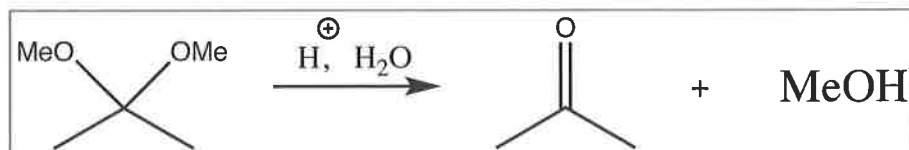
**\*\*Remember:** We protonate the carbonyl to make the reaction more favorable, and we drive off water (minus  $H_2O$ ) to make the entropy of the reaction better.



## 2.) Acetal Formation

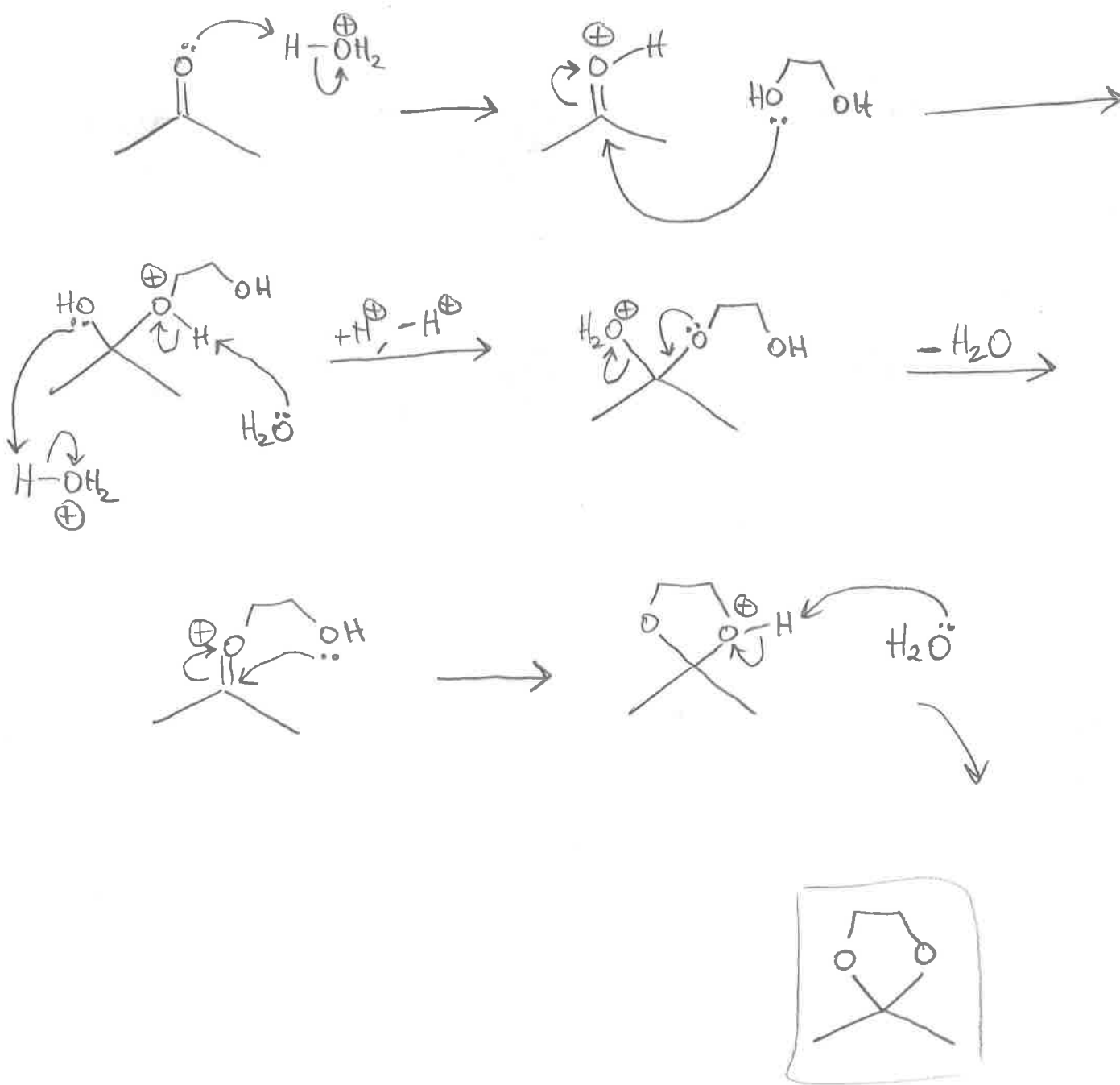
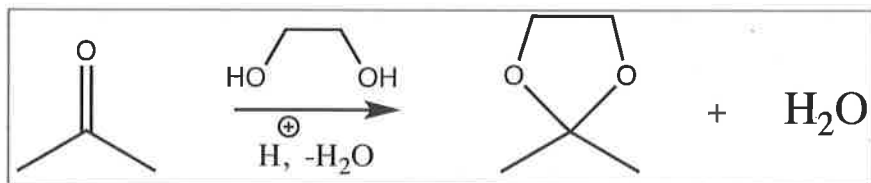
b.) Draw the **reverse** mechanism of Acetal Formation (remember, this only happens in an **Acidic Environment**) pictured below:

**\*\*Remember:** We subtract  $H_2O$  to help form an acetal, so we need to **add**  $H_2O$  in order to undo it and recover our carbonyl.



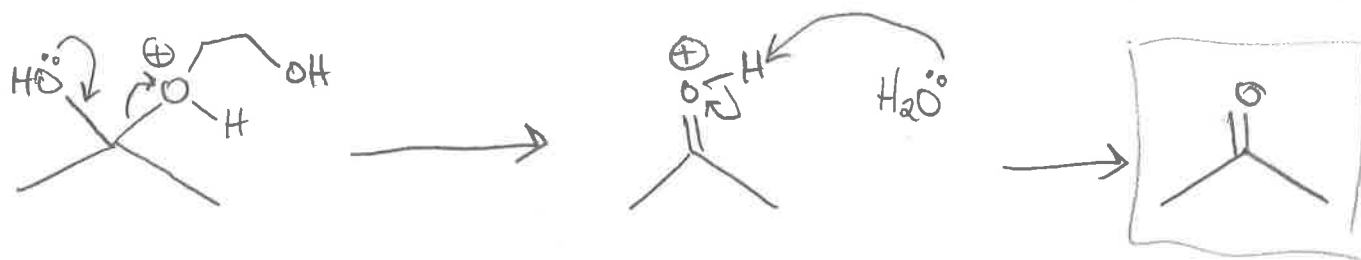
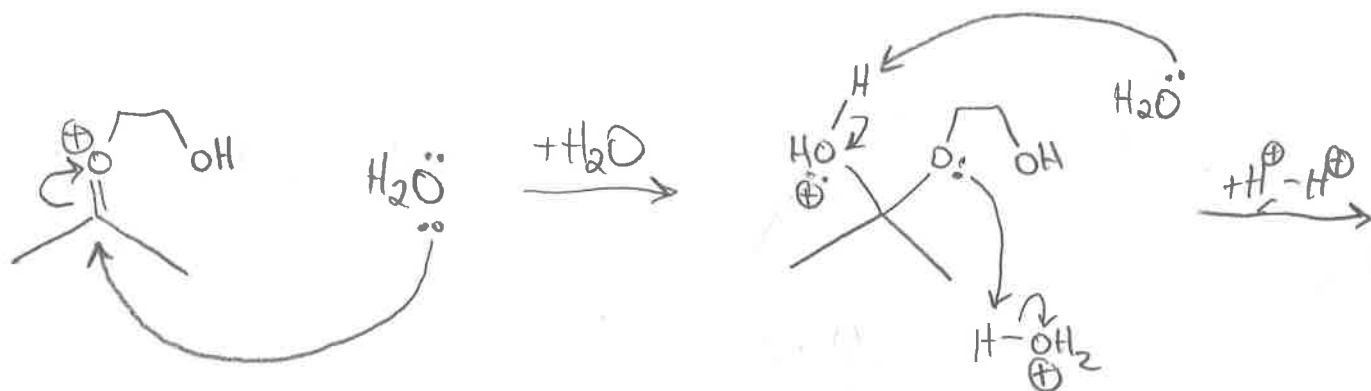
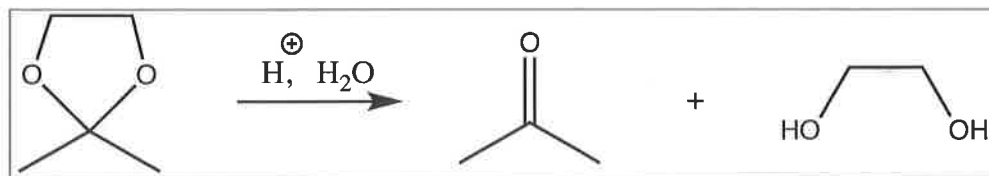
### 3.) Intramolecular Acetal Formation

a.) Draw the **forward** mechanism of the intramolecular Acetal Formation pictured below (I warned you that you would want to hurt me ☹):



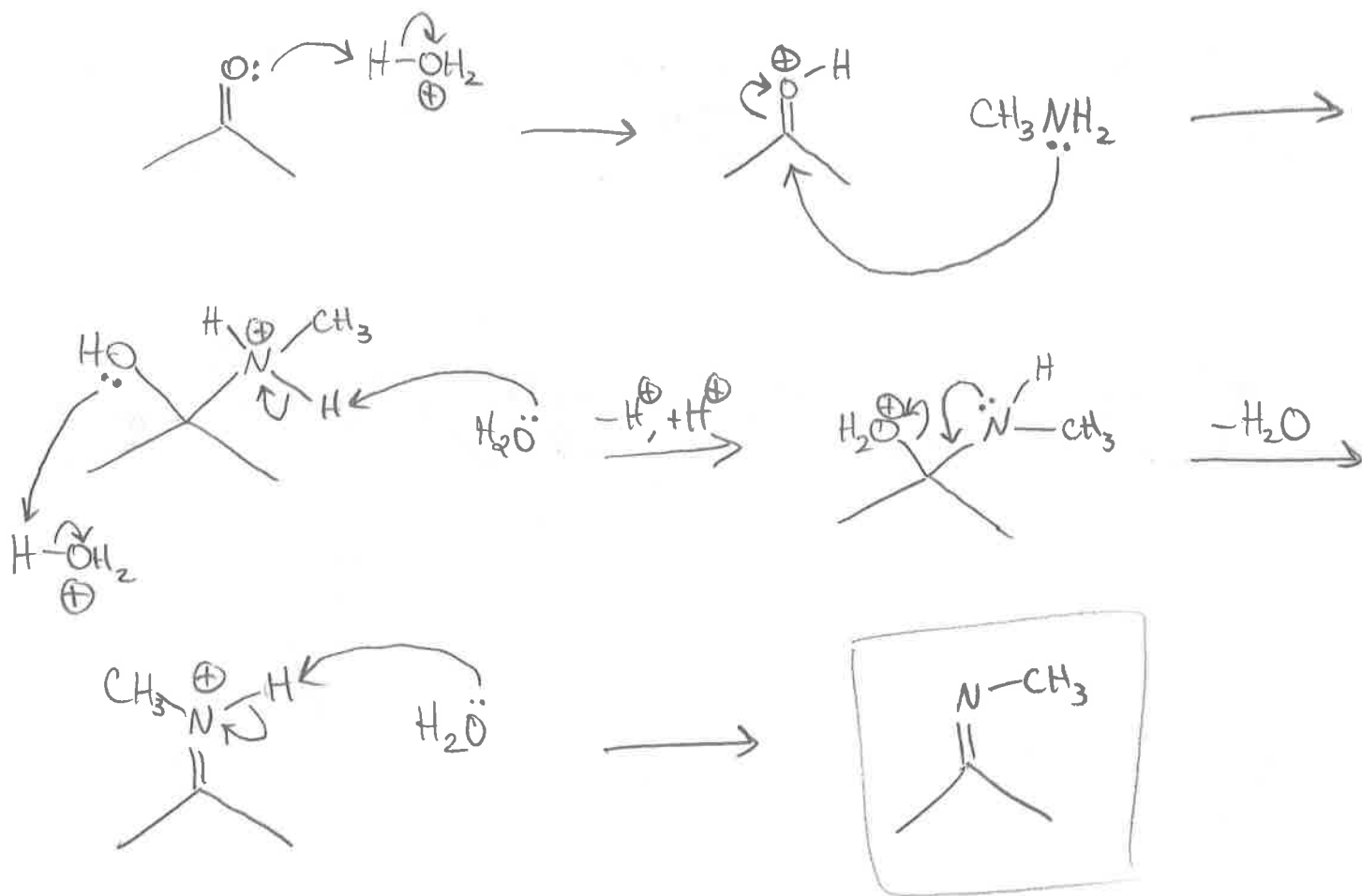
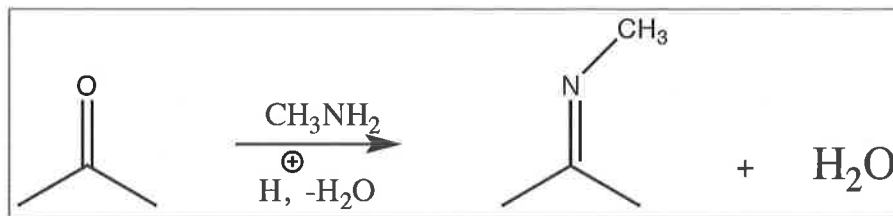
### 3.) Intramolecular Acetal Formation

b.) Draw the **reverse** mechanism of the intramolecular Acetal Formation pictured below (seriously, please don't hurt me I'm your organic friend):



#### 4.) Imine Formation

a.) Draw the **forward** mechanism of the Imine Formation pictured below (remember, this happens with ammonia or a primary amine):

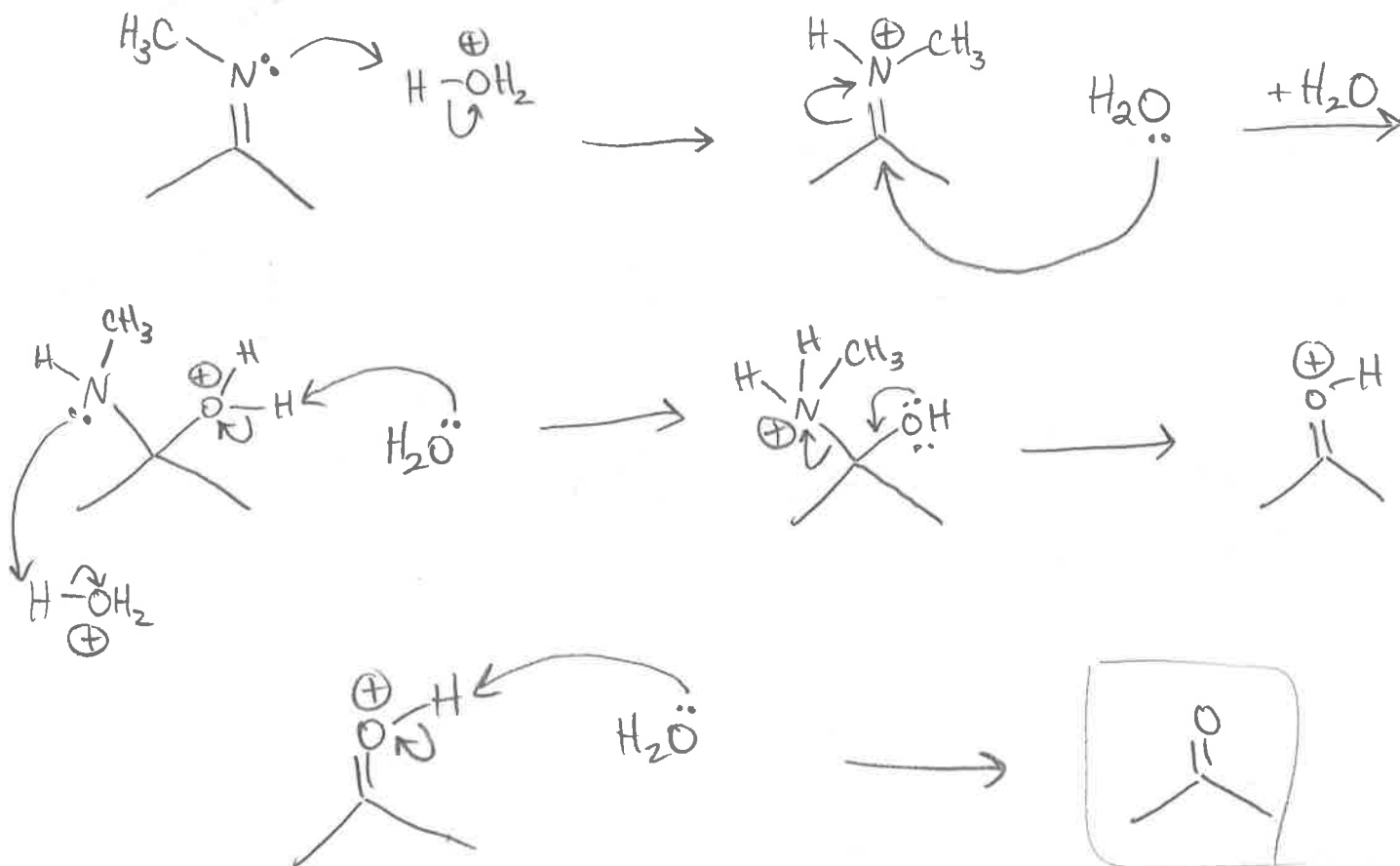
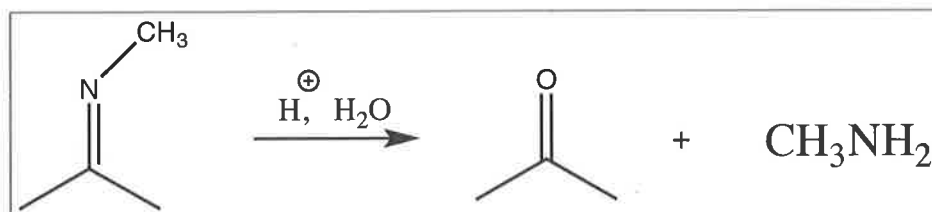




#### 4.) Imine Formation

b.) Draw the **reverse** mechanism of the Imine Formation pictured below (remember, this happens with ammonia or a primary amine):

**\*\*Same deal as the reverse acetal formation:** We subtract  $\text{H}_2\text{O}$  to help form an imine, so we need to **add**  $\text{H}_2\text{O}$  in order to undo it and recover our carbonyl.

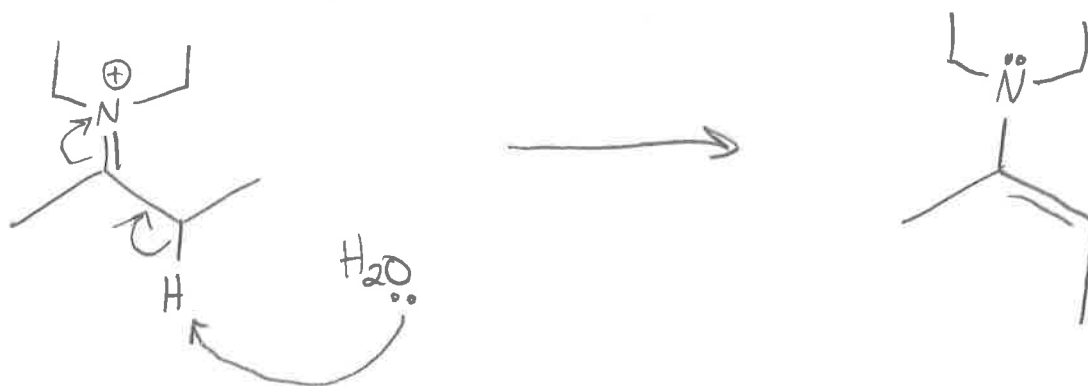
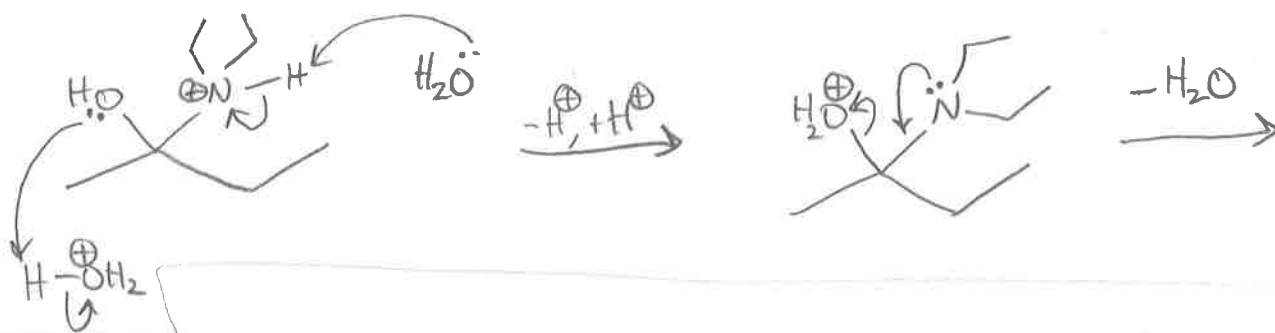
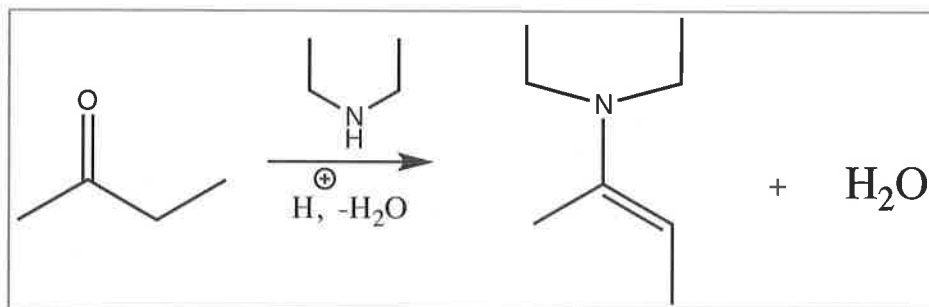


## 5.) Enamine Formation

a.) Draw the **forward** mechanism of the Enamine Formation pictured below (remember, this happens with a secondary amine **only**):

"trans"  
↓  
E double bond

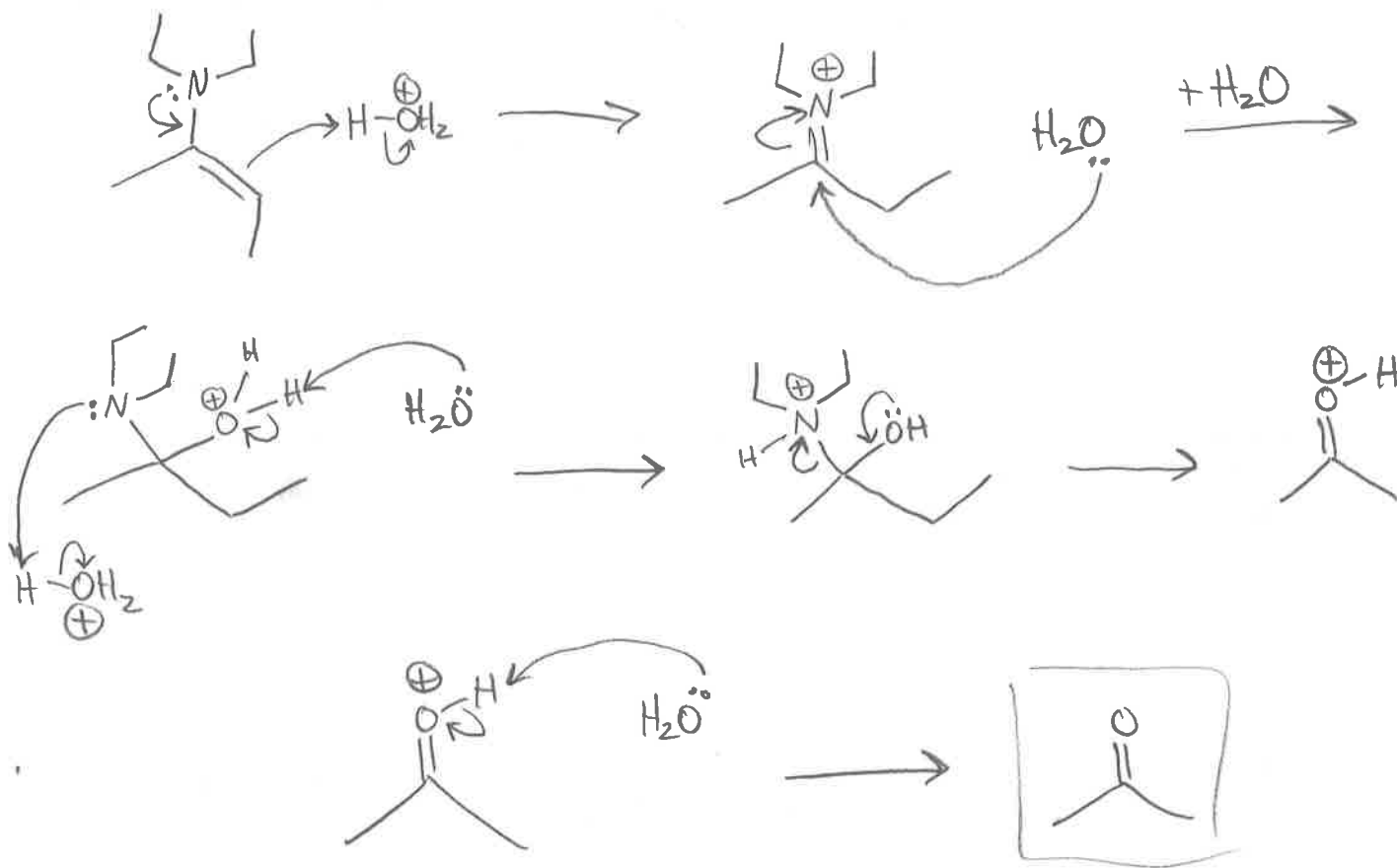
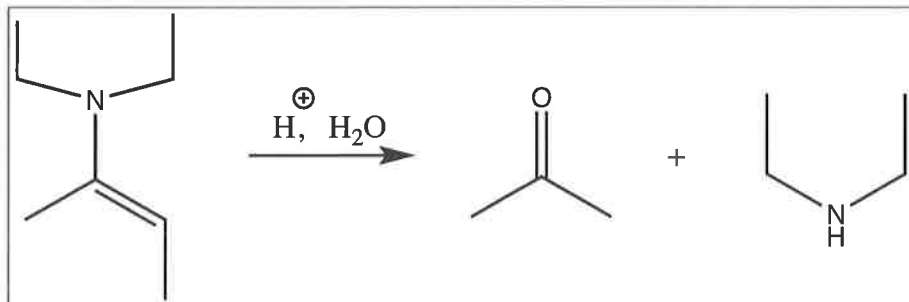
**\*\*Side Note:** I used 2-butanone here to emphasize how you make the double bond in an enamine.



## 5.) Enamine Formation

b.) Draw the **reverse** mechanism of the Enamine Formation pictured below (remember, this happens with a secondary amine **only**):

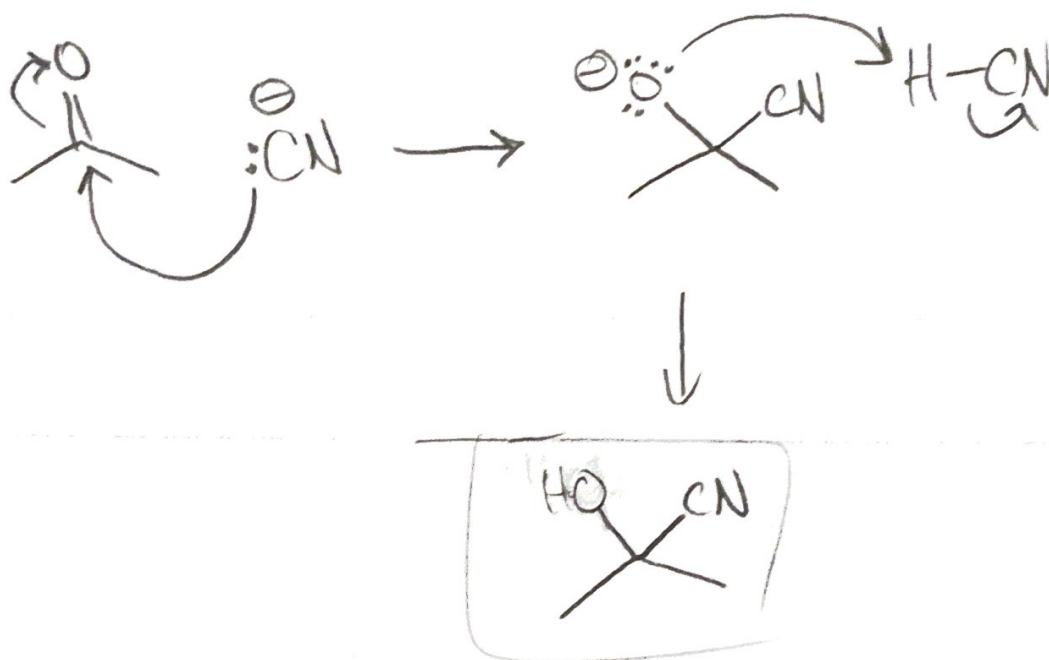
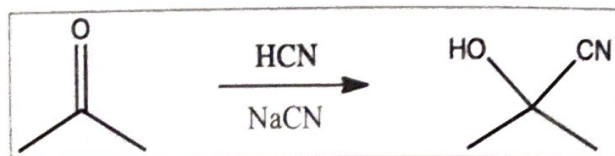
**\*\*Same deal as the reverse acetal/imine formation:** We subtract  $\text{H}_2\text{O}$  to help form an enamine, so we need to **add**  $\text{H}_2\text{O}$  in order to undo it and recover our carbonyl.



## 6.) Cyanohydrin Formation

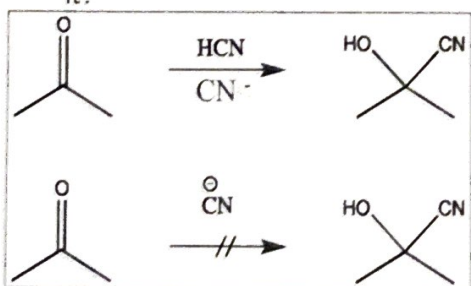
**\*\*THIS IS THE LAST ONE I PROMISE\*\***

a.) Draw the **forward** mechanism of the Cyanohydrin Formation pictured below:



b.) Okay, I'm done torturing you with mechanisms. But I have one last question:

- Briefly explain why Cyanohydrin Formation works when acid is present, but **fails** without it?



$\Rightarrow$  Oxygen is protonated & cyanohydrin formed

$\Rightarrow$  without protonation, carbonyl reforms & ejects  $:\text{CN}^-$  (good leaving group)

