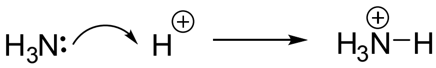
How to use curly arrows:

You should read each frame and answer the question while keeping the following frame covered.

1. The curly arrow  which chemists use to draw mechanisms means:

the movement of a pair of electrons from one end of the arrow to the other

So, when ammonia is protonated, the arrow moves from the lone pair of electrons on the nitrogen atom into the gap between N and H to make a new N-H bond:



The positive charge is now on nitrogen, because it has lost electrons.

Draw the protonation of benzylamine, $PhCH_2NH_2$

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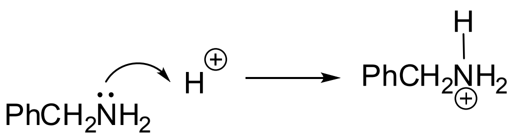
2. You should have drawn this:



The oxygen atom has lone pairs too. Draw the protonation of ether, Et_2O

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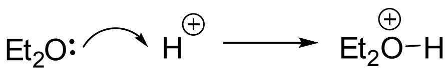
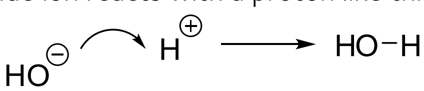
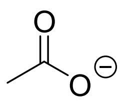
3. 

Sometimes the arrow starts on a negative charge, since this is a lone pair of electrons which can form a bond.

Hydroxide ion reacts with a proton like this:



Draw the protonation of acetate ion,



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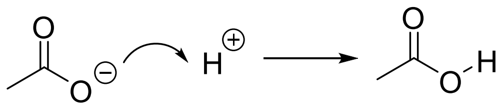
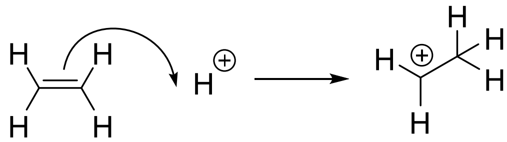
4.



We can use bonding electrons to form new bonds, as in the protonation of an olefin:



Note that the arrow begins this time in the middle of the bond. Draw the protonation of cyclohexene.

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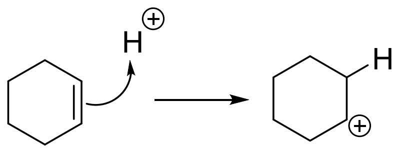
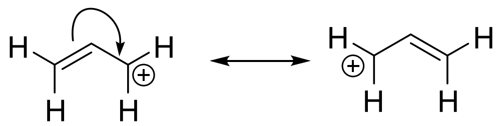
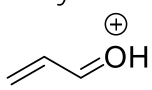
5.



These ions are very unstable and would in fact react further.
Some ions are more stable because of delocalisation; this can also be represented by curly arrows:



How would you show delocalisation in this ion:



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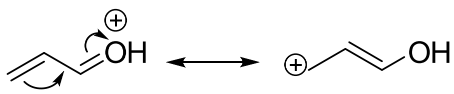
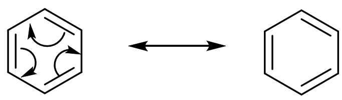
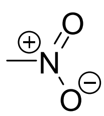
6.



These "reactions" do not produce *new* cations – they simply produce new ways of writing the old cation. The double-headed arrow ⟷ indicates this. Delocalisation occurs in neutral molecules too:



Show the delocalisation here:



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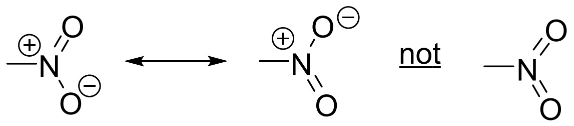
7.



which has 5-valent nitrogen

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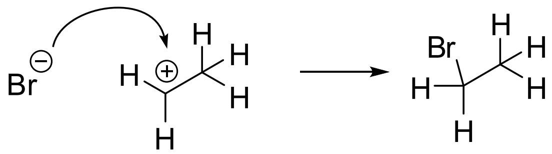
8. Now back to reactions. So far, we have used only one cation to accept electrons: $H^{\oplus}$ Other cations can of course behave in the same way. For example, the cation in frame 4 would react with bromide ion:



How would the same cation react with ammonia?

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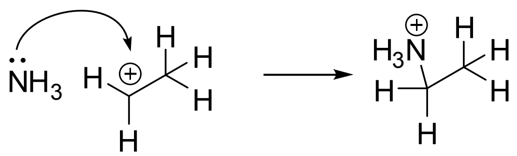
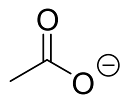
9.



You can see that we need a word for all these molecules which *donate* electrons to form new bonds: we call them *nucleophiles.* Molecules which *accept* electrons to form new bonds we call *electrophiles.*

Classify these reagents as nucleophiles or electrophiles:

$Br^{\ominus}$, NH_3, $CH_3CH_2^{\oplus}$, $H^{\oplus}$, $HO^{\ominus}$, $CH_2{=}CH_2$, 

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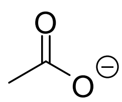
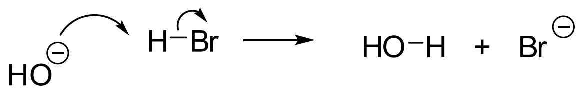
10.

Nucleophiles: $Br^{\ominus}$, NH_3, $HO^{\ominus}$, $CH_2{=}CH_2$, 

Electrophiles: $CH_3CH_2^{\oplus}$, $H^{\oplus}$,

Some electrophiles become electron-acceptors by breaking σ-bonds. So hydroxide attacks H-Br:



How would HBr react with NH_3?

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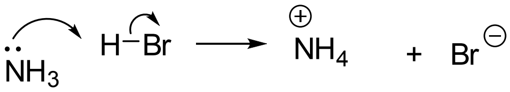
11.



Notice that we broke the H-Br bond to make stable $Br^{\ominus}$ and not unstable $H^{\ominus}$.
How would hydroxide ion react with CH_3-Br?

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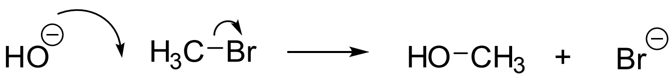
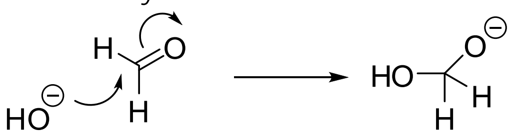
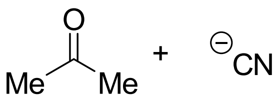
12.



Again, stable $Br^{\ominus}$ is preferred to unstable $CH_3^{\ominus}$.
Another way a molecule can become electrophilic is by breaking a π-bond:



What would happen here?



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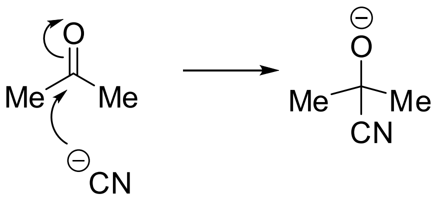
13.



If there were some acid present in solution to provide $H^{\oplus}$, what would happen now?

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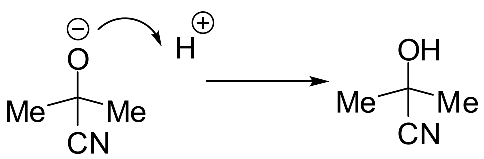
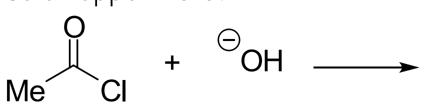
14.



If we have to choose between breaking a σ-bond and a π-bond we usually choose to break the π-bond because it is weaker.
What would happen here?



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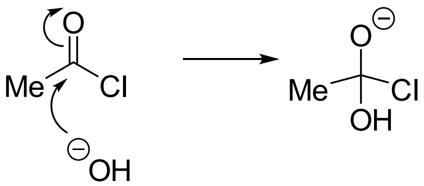
15.



The reaction does not stop here: $Cl^{\ominus}$ and CH_3COOH are the final products. Can you draw the arrows for this?

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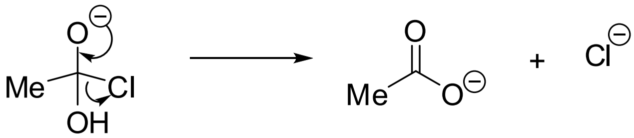
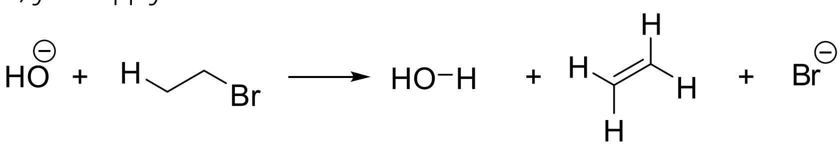
16.



Let's use this method for a more complicated example: I'll give you the reagents and products, you supply the arrows:



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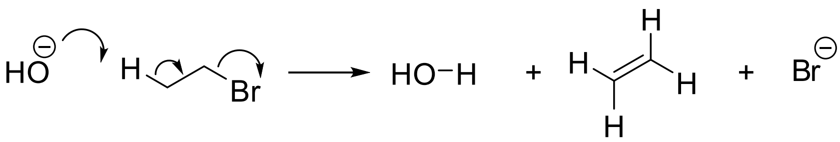
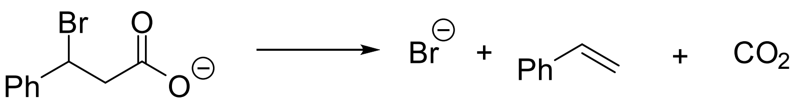
17.



Here the middle of the three arrows is something new: we simply moved the σ-bond along. This is quite a common feature in reactions. To end with provide the arrows here:



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18.