3. Focus on the rate-determining step (RDS) in this nucleophilic aromatic substitution process that goes by addition-elimination here.

RDS is cyclohexadienyl anion formation — this is accelerated by electron withdrawing substituents. To examine the rate of the process, it is the ELECTRONEGATIVITY of \( X \) (not its leaving group ability) that is important.

The cyclohexadienyl anion will be inductively stabilized by an eguy (X) here. F is the most eguy here so it will stabilize the anion the most.

It is important to note that the leaving group is not lost until AFTER the RDS. Therefore, leaving group ability of \( X^\ominus \) does not impact overall rate of the reaction.
There are two ways that the nucleophile can add to get resonance stabilization of the Meisenheimer complex by the -NO₂ groups.

This is one of 6 resonance structures for this Meisenheimer complex. Two others have the Θ on one of the other -NO₂ groups. Three res. structures have the Θ on one of the NO₂-bearing carbons. Be sure you can generate all of these res. structures.

There are 5 other res. structures for this Meisenheimer complex. Note that this Meisenheimer complex will not lead to a substitution reaction because methoxide and NEVER hydride (H⁻) (terrible leaving group) will be the leaving group when aromaticity is restored.
5. Hydration produces the final products:

\[
\text{\begin{align*}
\text{\ce{\text{\Delta}}} & \text{ acid or base} \\
\text{\ce{\text{\Delta}}} & \text{catalyzed}
\end{align*}}
\]

But need to look at the rate determining step to answer this question:

- RDS is addition of H₂O as a nucleophile to form a tetrahedral intermediate.

The energies of the two tetrahedral IM's are roughly similar; however, cyclobutanone is appreciably higher in energy than cyclohexanone. This is due to the strain in the smaller ring. The sp²-hybridized C in the starting ketones wants to (ideally) have 120° bond angles. In cyclobutanone, this is virtually impossible. So the amount of energy released by changing to an sp³-hybridized C (bond angles ~109°) is much greater for cyclobutanone than cyclohexanone. <over>
Thus, $\text{\textbullet}$ is likely to be more hydrated than is $\textcircled{O}$. 

The overall $\Delta G_{rxn}$ for $\text{\textbullet} \rightarrow \text{\textbullet}_{\text{\textbullet}}^\text{\textbullet}$ will be more negative than $\Delta G_{rxn}$ for $\text{\textbullet} \rightarrow \text{\textbullet}^\text{\textbullet}$.