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1. In an S_N2 reaction in which OH^- is the nucleophile, in which solvent will the rate be the fastest?
 - ▷ **a polar aprotic solvent**
 - ▷ a nonpolar solvent
 - ▷ a polar protic solvent
 - ▷ **Polar aprotic solvents:** protic solvents lacking a hydrogen atom connected to electronegative atoms.
 - Lack of hydrogen **fails to stabilize added nucleophiles**, leaving compounds with higher potential energy and thus a **lower activation energy** for a reaction to take place.
 - S_N2 reactions are generally much **faster in polar aprotic solvents**.
2. The carbon center in an alkyl halide is
 - ▷ an unsaturated center
 - ▷ a nucleophile
 - ▷ a cation
 - ▷ **an electrophile**
 - ▷ **Alkyl halides:** compounds in which a halogen (Cl, Br, I) is connected to an sp^3 hybridized carbon atom.
 - Alkyl halides are electrophiles since they contain such electron deficient halogens—making them easily accept new electrons.
3. Why is the rate of reaction for an S_N2 reaction so much slower for a 3° alkyl halide than for a 1° alkyl halide?
 - ▷ the leaving group is more reactive in an 1° alkyl halide
 - ▷ steric crowding is much less in 3° alkyl halides
 - ▷ because ΔG° is much smaller for a 3° alkyl halide
 - ▷ **steric crowding is much greater in 3° alkyl halides**
 - ▷ The more substituents, the more bonds that need to be broken/changed and the more steric interactions there are during the transition state—leading to higher activation energy and thus a slower reaction.
 - Steric crowding refers to the steric interactions that act to increase such interference.
 - 3° refers to the number of β positions (max 3° , min 1°)

- **α position:** the position connected directly next to the halogen.
- **β position:** positions connected to the α position.

4. At the transition state of an S_N2 reaction reaction

- ▷ **the C–Nu bond is *partially* formed and the C–LG bond is *partially* broken.**
- ▷ the C–Nu bond is *partially* formed and the C–LG bond is *completely* broken.
- ▷ the C–Nu bond is *completely* formed and the C–LG bond is *partially* broken.
- ▷ the C–Nu bond is *partially* formed and the C–LG bond is *completely in tact*.
- ▷ **Transition states:** represent local maxima of the reaction.
 - Cannot be isolated.
 - Represents high-energy states where bonds are being simultaneously broken and formed.
 - I.e., partially broken and partially formed.

5. The rate law expression for an S_N2 reactions reaction has the form

- ▷ rate = $k[\text{electrophile}]$
- ▷ rate = $k[\text{electrophile}]^2$
- ▷ rate = $k[\text{nucleophile}]^2$
- ▷ **rate = $k[\text{electrophile}][\text{nucleophile}]$**
- ▷ **Kinetics of S_N2 reactions:** a biomolecular (2) nucleophilic (N) substitution (S) reaction.
 - **Biomolecular:** a step that involves two chemical entities, such as when the alkyl halide and nucleophile collide during the reaction mechanism.
 - Rate: $v_0 = k[\text{alkyl halide}][\text{nucleophile}]$
 - As mentioned above, alkyl halides are electrophiles.

6. What is the meaning of S_N2 ?

- ▷ substitution nucleophilic two transition states
- ▷ substitution nucleophilic two two reagents
- ▷ **substitution nucleophilic two second order**
- ▷ substitution nucleophilic two twice
- ▷ $\text{Rate} = k[A]^x[B]^y$
 - **Rate order**: the sum of exponents of the reactants.
 - E.g., kA = first, kAB = second, kA^2B = third.

7. Which would you expect to be the best nucleophile?

- ▷ F^-
- ▷ $(CH_3)_2CH^-$
- ▷ **CH_3^-**
- ▷ $(CH_3)_3C^-$
- ▷ **Nucleophilicity**: the rate at which a nucleophile will attack a suitable electrophile.
 - There are multiple factors that contribute, but three main factors at play here: the role electron density, electronegativity, and steric hindrance (crowding).
 - $(CH_3)_2CH^-$ (2°) and $(CH_3)_3C^-$ (3°) have more β branching, thus more hindrance.
 - F^- electron density is so small that it causes low polarizability (more stable), which reduces reactivity.
 - Nucleophilicity also decreases as electronegativity increases ($F > O > N > C$), so carbon will have higher Nucleophilicity.

8. In substitution reactions with alkyl halides,

- ▷ the nucleophile is the leaving group
- ▷ a hydrogen becomes the leaving group
- ▷ **the halide is the leaving group**
- ▷ the electrophile is the leaving group
- ▷ In an alkyl halide, the halogen serves two critical functions that render the alkyl halide reactive:
 - The halogen withdraws electron density via **induction**, rendering the adjacent carbon atom electrophilic, and therefore subject to attack.

- The halogen can serve as the **leaving group** for the compound, vital for substitution or an elimination to occur.
 - Good leaving groups are conjugate bases of strong acids, i.e., good groups are weak bases.
 - Generally an acid with a $pK_a < 0$ generates a stable enough base to be a good leaving group, which is another reason why F (pK_a of HF is 3.2) is not one, despite being a halogen.

9. Of the following, which is the better nucleophile?

- ▷ H_2O
- ▷ NH_3
- ▷ RNH^-
- ▷ **NH_2^-**
- ▷ This question has more to do with the solvent effects on nucleophilicity.
 - **Protic solvents:** polar solvent that **contains** a hydrogen atom connected directly to an electronegative atom.
 - **Polar aprotic solvents:** protic solvents **lacking** a hydrogen atom connected to electronegative atoms.
 - Both H_2O and NH_3 have are protic solvents, with hydrogen on the electronegative oxygen and nitrogen.
- ▷ Comes down to RNH^- and NH_2^- .
 - I believe the R is a functional group, which shares more of the negative charge, decreases strength relative to NH_2^-
 - Although, I'm not completely sure, and I welcome a better explanation.