POLAR PROTIC VS. POLAR APROTIC SOLVENTS
Problems document

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This video is intended for students who find this material to be difficult, so in the video I proceed slowly and repeat myself a lot. If you find the video to move too slowly, you can simply try the problems in this Problems document, check your answers against the Answers document, and skip to the video explanation for any problems that you find confusing.

There is a table of contents for the video in the progress bar at the bottom of the video. You can use this table of contents to find particular problems you want to review.

SUMMARY OF TOPICS COVERED IN THIS VIDEO:

Polar protic solvents contain O-H or N-H bonds.
Polar aprotic solvents do not contain any O-H or N-H bonds.

S_N2 reactions occur more quickly in polar aprotic solvents than in polar protic solvents.
The reason is that a polar protic solvent creates a tight solvation “shell” around the nucleophile that hinders the nucleophile from attacking the α carbon.
At the end of the video, we will discuss *why* a polar protic solvent solvates the nucleophile more tightly than a polar aprotic solvent.

S_N1 reactions occur more quickly in polar protic solvents than in polar aprotic solvents.

NOT COVERED IN THIS VIDEO:
The *reason* that S_N1 occurs more quickly in a polar protic solvent is not covered in this video, because the reason for the S_N1 solvent pattern is more subtle and less frequently tested than the reason for the S_N2 solvent pattern. If you are interested, you can find the reason in your textbook.

This video builds on the ideas we covered in the previous video series on S_N2 and S_N1 reactions, so you may find it helpful to watch those series before watching this video.

Problems begin on next page.

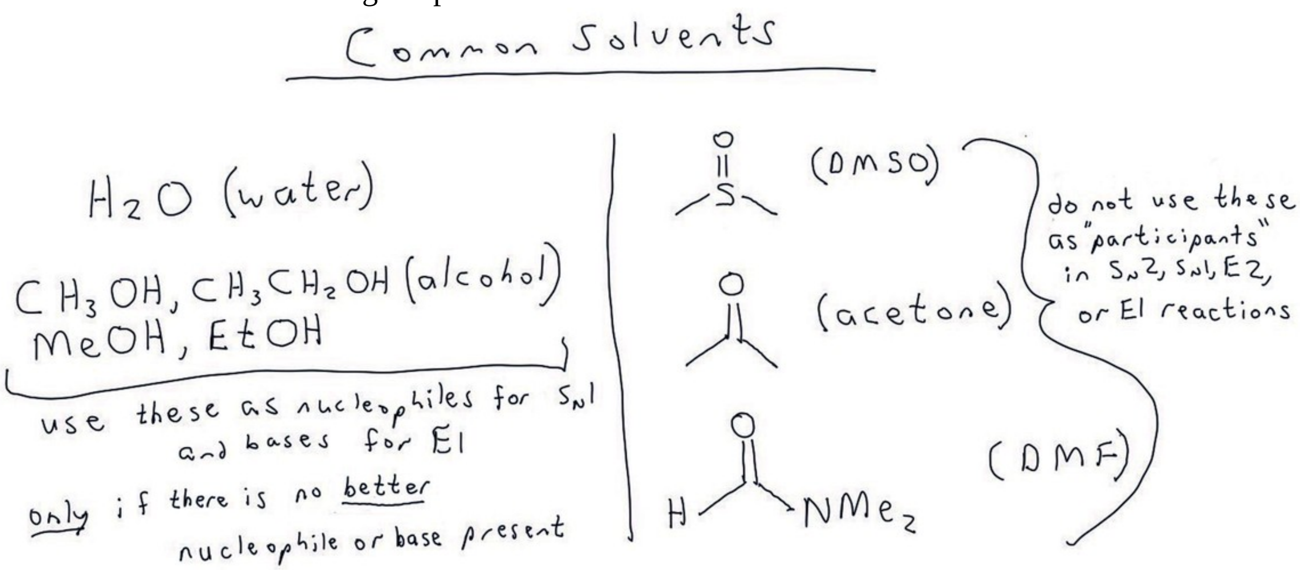
Problem (a)

What is a polar molecule?

How does the electronegativity of hydrogen compare to the electronegativity of carbon?

What does “more electronegative” mean?

Which of the following are polar solvents?



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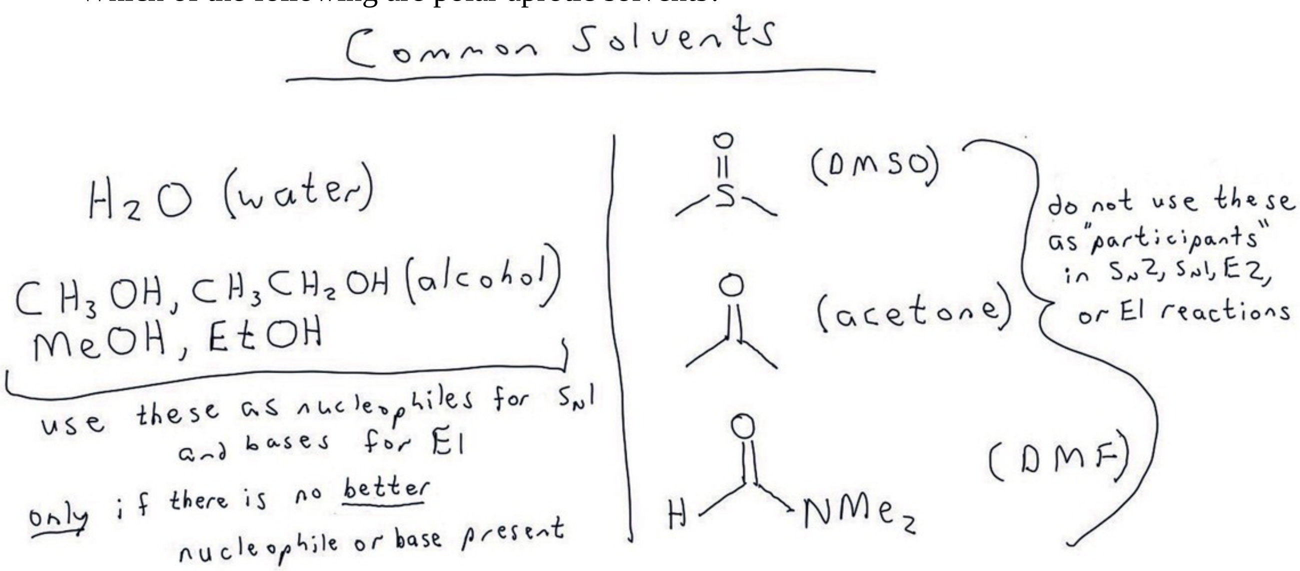
Problem (b)

How can you determine whether a solvent is “protic” or “aprotic”?

Which of the following are polar protic solvents?
Which of the following are polar aprotic solvents?



Is an S_N2 reaction faster in a polar protic solvent or in a polar aprotic solvent?
Is an S_N1 reaction faster in a polar protic solvent or in a polar aprotic solvent?

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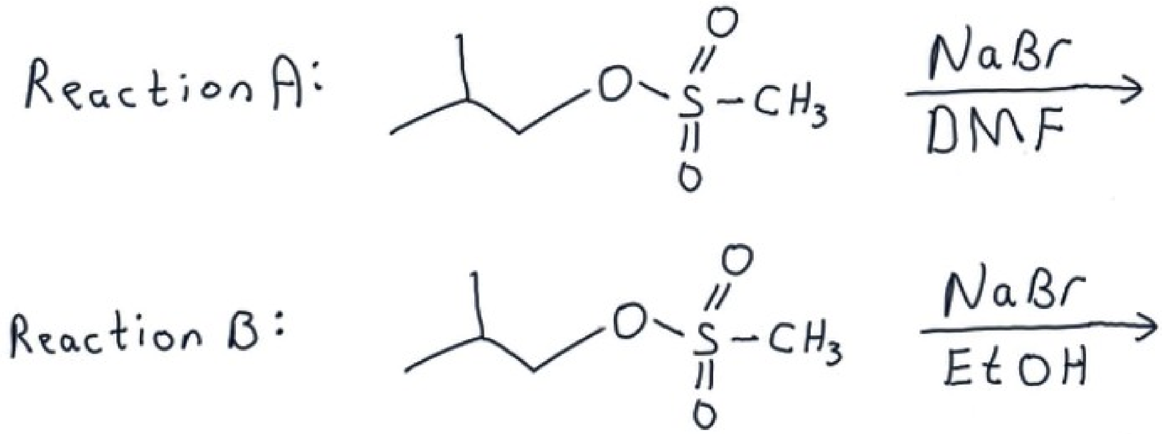
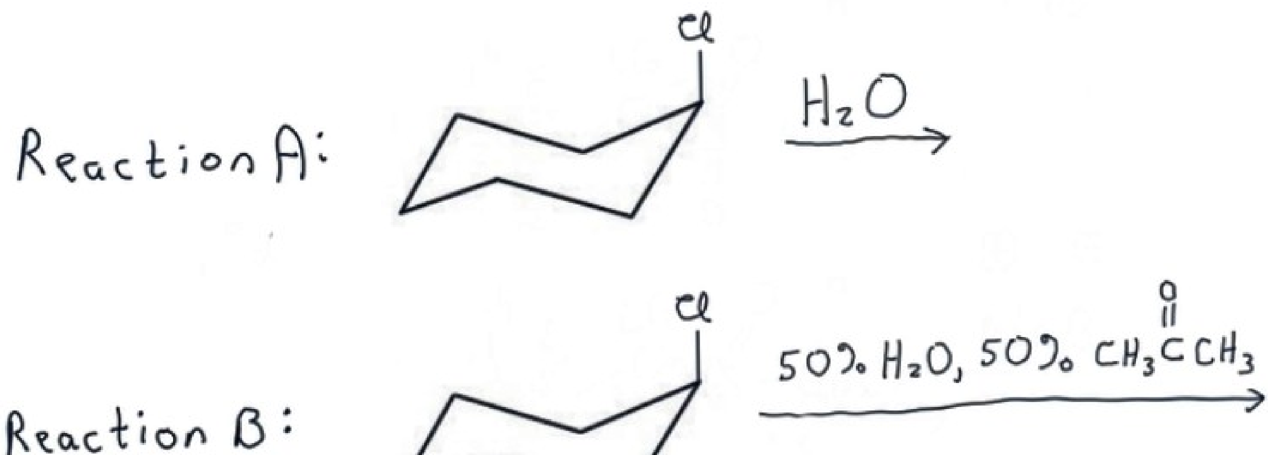
Problem (c)

For the reactions below, which reaction will occur at the faster rate?



Problem (d)

For the reactions below, which reaction will occur at the faster rate?



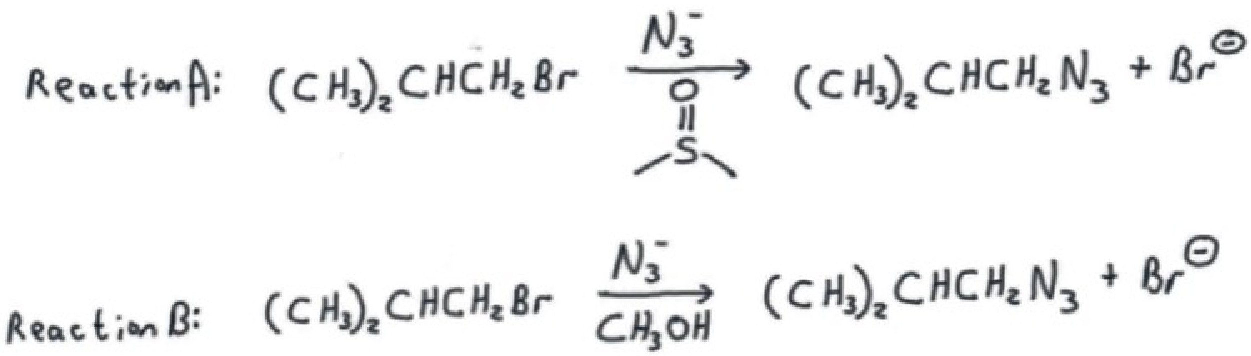
Problem (e)

What is the "big obstacle" to an S_N2 reaction? Why?

Explain *why* an S_N2 reaction is faster in a polar aprotic solvent than in a polar protic solvent.

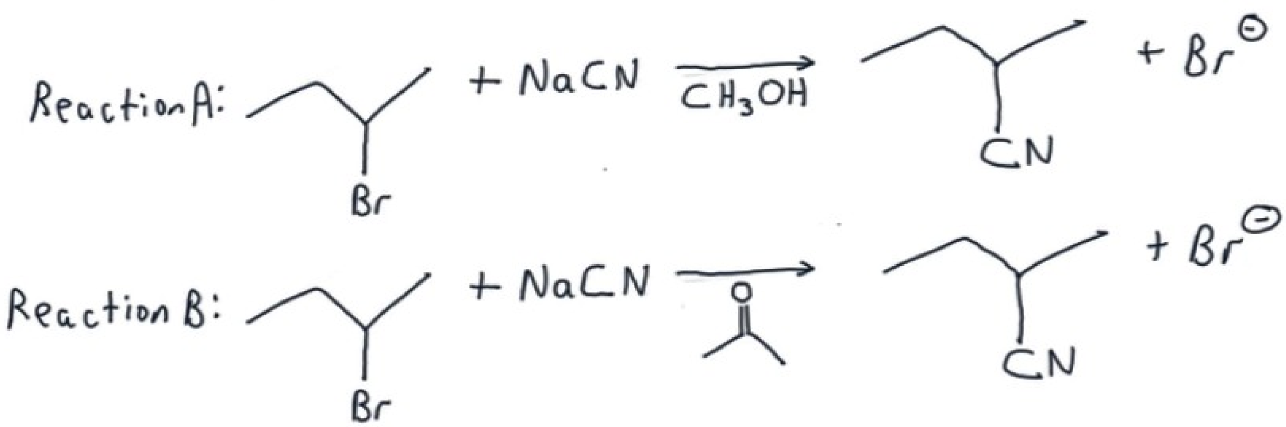
Problem (f)

For the reactions below, which reaction will occur at the faster rate? Justify your answer.



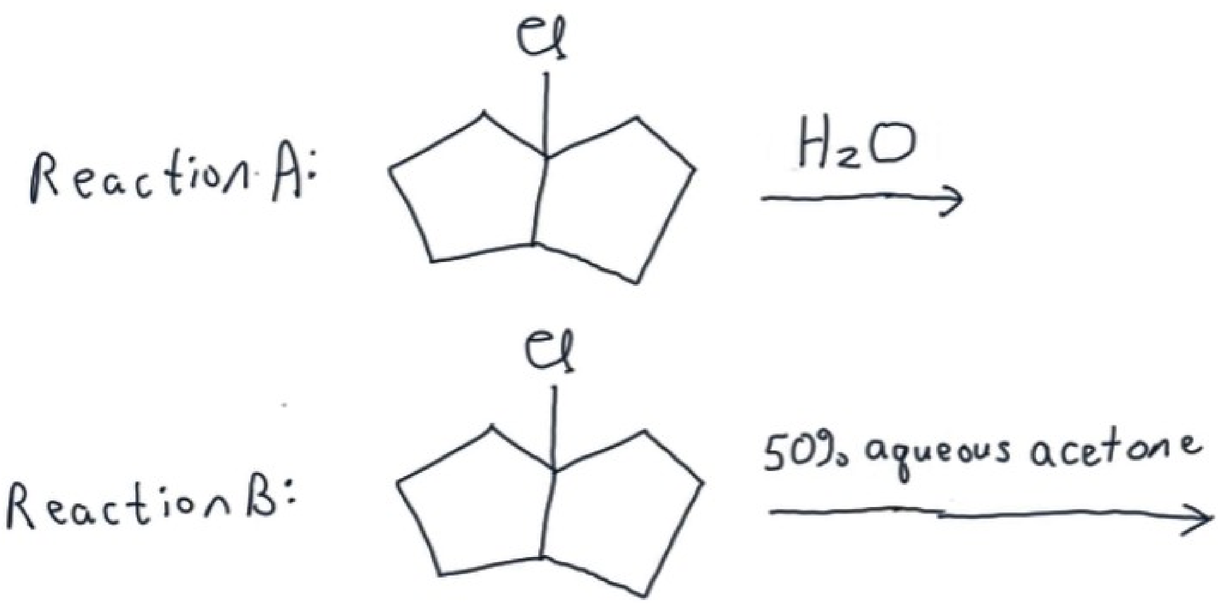
Problem (g)

For the reactions below, which reaction will occur at the faster rate? Justify your answer.



Problem (h)

For the reactions below, which reaction will occur at the faster rate?



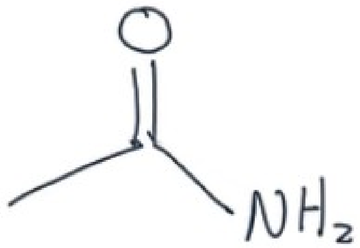
Problem (i)

Steric hindrance is a big obstacle to an S_N2 mechanism, but steric hindrance is not a big obstacle to an S_N1 mechanism. Explain the difference.

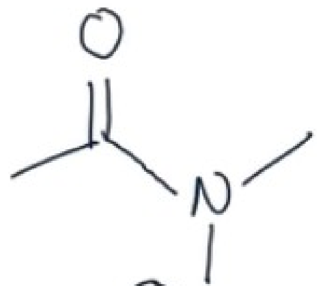
A polar protic solvent slows down an S_N2 mechanism, but a polar protic solvent does not slow down an S_N1 mechanism. Explain the difference.

Problem (j)

Choose the best solvent for an S_N2 reaction. Justify your answer.



A



B

H_2O

C

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A polar protic solvent solvates a nucleophile more tightly than does a polar aprotic solvent because a polar protic solvent can form hydrogen bonds to the nucleophile. The remaining problems in this document explore the importance of hydrogen bonding for this solvent effect.

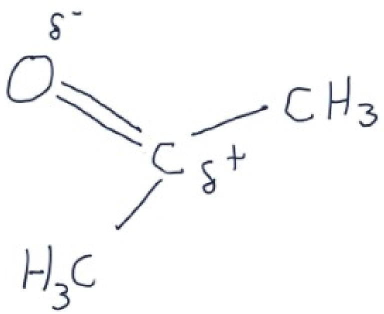
You probably won't need to know the following material to get S_N2 solvent problems right on your exam. The following material is included mainly for those who are interested in deepening their understanding of hydrogen bonds, rather than for preparing for S_N2 solvent problems on exams. Hydrogen bonds are an important topic in many areas of organic chemistry and biochemistry.

Problem (k)
What is a hydrogen bond?

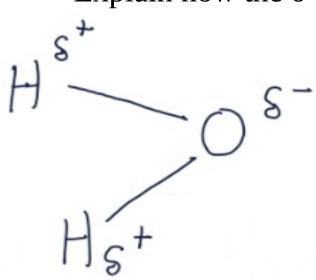
Can polar protic solvents engage in hydrogen bonding?
Can polar aprotic solvents engage in hydrogen bonding?

Why do polar protic solvents create a tight solvation shell around the nucleophile?
Why don't polar aprotic solvents create a tight solvation shell around the nucleophile?

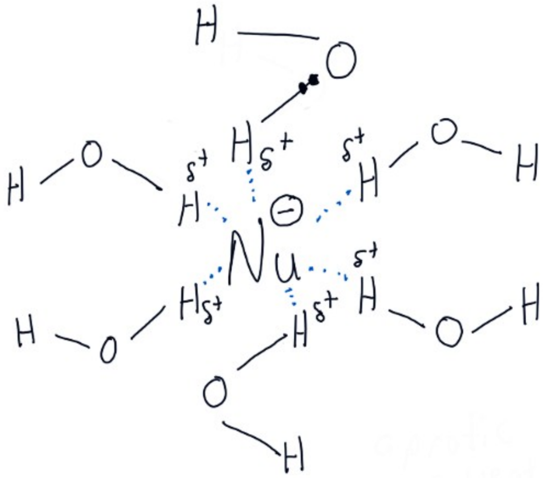
Problem (l)
Explain how the δ charges in acetone, shown below, are determined.

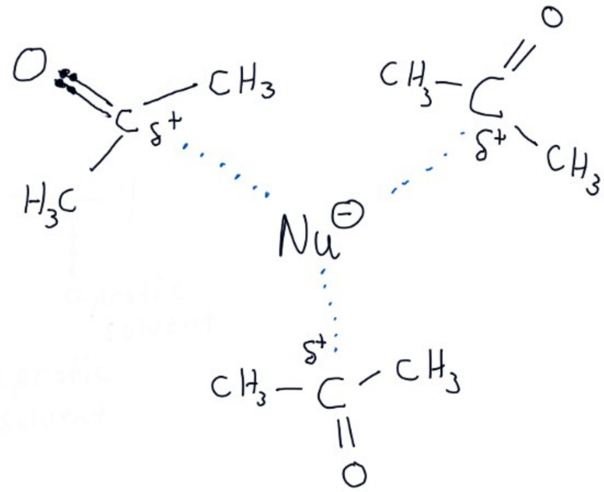


Explain how the δ charges in water, shown below, are determined.



Problem (m)





In the left picture, the dots represent hydrogen bonds.

In the right picture, the dots represent “ion-dipole interactions”, which are looser than hydrogen bonds.

Why are hydrogen bonds (in the left picture) a stronger, tighter interaction than ion-dipole interactions (in the right picture)?