Midterm 1 Review Packet Key

1. Rank the following molecules from best to worst leaving group. Explain.

<table>
<thead>
<tr>
<th>Cl⁻</th>
<th>Br⁻</th>
<th>F⁻</th>
<th>I⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

   As basicity increases, the leaving group ability decreases.

2. Which of the following is the strongest nucleophile. Explain.

   CH₃CH₂O⁻ is the strongest nucleophile because it is less bulky than the other molecules. As the bulkier it gets, the harder it is to attack the substrate.

3. Which of the following molecules are the fastest under SN2.

   1-chloro-2-methyl-hexane undergoes the fastest under SN2 because it’s alkyl halide is a primary alkyl halide which is favored by SN2.

   Are there any compounds that does not undergo SN2 reaction? Why or why not?

   This molecule cannot undergo an SN2 reaction because the alkene prevents any nucleophile from undergoing a backside attack.

4. Will this reaction undergo SN2, SN1, E2, or E1? Then draw the product of the mechanism.

   a)
This reaction undergoes SN2 as the substrate has a primary alkyl halide. The reaction also has a strong nucleophile along with an apolar aprotic solvent which favors SN2 as they do not solvate and thus weaken the nucleophile.

![SN2 mechanism diagram]

This reaction undergoes an SN1 as the substrate has a 3° alkyl halide. The nucleophile is also a weaker nucleophile.

5. Identify which mechanism this reaction will undergo. Draw the product(s) of the following reaction.

![SN1 mechanism diagram]

This reaction underwent an E2 mechanism due to its strong bulky base. There are two possible products that were produced with this reaction as there are multiple β-hydrogen that can be attacked. However, the one that is most favored is the first product shown due to Zaitsev’s Rule as this product had the most substituents in the newly formed alkene.

6. Draw the product of the following reaction along with the mechanism that leads to the product.

![E2 mechanism diagram]

b) The rate reaction of this equation would be \( R = k[C-x][\text{MeO}^-] \)

c) Since this is an SN2 reaction, both the alkyl halide and the nucleophile concentrations changes the rate of reaction. So if alkyl halide is doubled, the reaction rate increases. If the nucleophile is doubled, the reaction rate increases as well.

7. Draw the arrow pushing mechanism for the following SN2 reaction. Explain how you know this reaction is SN2.
1. Product does not contain alkene → NOT elimination reaction
2. Secondary alkyl halide → can undergo SN1 or SN2
3. Strong base → can directly attack alkyl halide in the first step
4. Polar aprotic solvent → favors SN2 reactions

8. Draw the arrow pushing mechanism for the following SN1 reaction. Explain how you know this reaction is SN1.

1. Product does not contain alkene → NOT elimination reaction
2. Tertiary alkyl halide → too sterically hindered to undergo a backside attack with an SN2
3. Weak base → not strong enough to attack the alkyl halide as the first step
4. Polar protic solvent → favors SN1 reactions

9. Circle the following solvent(s) that are polar aprotic. Explain how this conclusion was made.

Polar aprotic solvents lack hydrogens that are directly attached to electronegative atoms making them unable to create hydrogen bonds due to the lack of a hydrogen to donate.
10. How will the following changes in the conditions affect the rate of the reactions below? [“Slower”, “Faster”, “No Change”]

Methanol was used in place of acetone  | slower  
Concentration of hydroxide was tripled  | faster  
Water was used in place of hydroxide  | slower 

11. Will the following substrates undergo an SN1 or SN2 reaction? Explain.

SN2 because…
1. Secondary alkyl halide → can undergo SN1 or SN2
2. Strong base → can directly attack alkyl halide in the first step
3. Polar aprotic solvent → favors SN2 reactions, no hydrogen directly bonded to electronegative atom

12. Propose an alkyl halide and nucleophile (over the arrow) that will react to produce the following compounds as major products. Name the mechanism (under the arrow). Show stereochemistry if necessary.

13. Identify the mechanism of the following reaction and write the name in the box under the arrow. Draw the reaction products according to your prediction. Circle the expected major product. Show stereochemistry, if applicable.

1) We need to identify the alkyl halide: 2°
2) Look at the nucleophile/base to determine which mechanism it will undergo. If there was a solvent, we would look at that too: tert-butoxide indicates a strong bulky base, which E2 mechanisms LOVE

3) Label all beta-H’s

4) Remember Zaitsev’s rule when determining major and minor products: the more substituted alkene is the more stable one

Major Product Mechanism:

Minor Product Mechanism:

14. Draw the products of this SN1 reaction:
3° alkyl halide, weak nucleophile, and a polar protic solvent (water acts as the nucleophile & solvent).
SN1 reactions attack from both the frontside and backside, resulting in racemization of the stereocenter.

The products are enantiomers.

15.  
   a. Which compound undergoes the fastest SN2: 2  
   b. Which compound undergoes the fastest E2: 3  
   c. Which compound(s) can form more than one product upon elimination: 1, 3  
   d. Which compound(s) do(es) NOT undergo SN2 reaction(s): 3  
      3° alkyl halides do not undergo SN2-- only methyl, 1°, and 2° alkyl halides  
   e. Which compound(s) do(es) NOT undergo E1 reaction(s): 2  
      1° alkyl halides do not undergo E1 reactions-- only 3° and 2° alkyl halides
16. For each reaction, use the identity of the alkyl halide and nucleophile to determine which substitution mechanism occurs. Then determine which solvent affords the faster reaction.

a. 

\[
\text{Br} + \text{OH}^− \xrightarrow{\text{H}_2\text{O} \text{ or DMF}} \text{OH} + \text{Br}^−
\]

**Strong nucleophile + \(1^\circ\) alkyl halide = SN2 so we need an apolar protic solvent such as DMF.**

b. 

\[
\text{Cl} + \text{CH}_3\text{OH} \xrightarrow{\text{CH}_3\text{OH} \text{ or DMSO}} \text{CH}_3\text{O} + \text{HCl}
\]

**Weak nucleophile + \(3^\circ\) alkyl halide = SN1 so we need a polar protic solvent such as methanol. In a lot of cases with SN1 reactions, the nucleophile also acts as the solvent.**

17. Draw curved arrows to show the movement of electrons in the following reaction:

18. Answer the following questions with SN2, SN1, E2, and E1. Some questions may have more than one mechanism.

a. Primary alkyl halide, strong nucleophile: SN2
b. Primary alkyl halide, strong bulky base: E2
c. Secondary alkyl halide, strong base and nucleophile: SN2, E2
d. Secondary alkyl halide, strong bulky base: E2
e. Secondary alkyl halide, weak base and nucleophile: SN1, E1
f. Secondary alkyl halide, weak bulky base: E1
g. Tertiary alkyl halide, weak base and nucleophile: SN1, E1
h. Tertiary alkyl halide, weak bulky base: E1
i. Tertiary alkyl halide, strong base: E2