Statistics: High score, average, and low score will be posted on the course web site after exam grading is complete.

Some questions have more than one answer, even though only one answer may be listed here.

To see the projected final course grade cutoffs, consult the grading scale on the Chemistry 14D course web page.

1. Iodide ion is displaced before chloride ion because iodide ion is a better leaving group than chloride ion. Ammonia is the base for the proton transfer step because ammonia is the strongest base present.

2. (a) \((\text{ICH}_2\text{CH}_2)_2\text{NH}_2^+\), is not produced in this reaction because iodide ion is a better leaving group than chloride ion.

   (b) This reaction does not proceed via an \(S_N1\) mechanism because this would involve a primary carbocation, and primary carbocations without resonance are generally too unstable to form.

3. (a) D (rate decreases). \(\text{PhNH}_2\) is a poorer nucleophile than \(\text{NH}_3\) due to resonance delocalization of the nitrogen lone pair by the benzene ring. In addition, \(\text{PhNH}_2\) is more sterically hindered than \(\text{NH}_3\).

   (b) D (rate decreases). The transition state has \(\delta^+/\delta^-\) charges whereas the reactants are uncharged. A polar solvent stabilizes the transition state more than the reactants, increasing the reaction rate. Hexane is much less polar than DMF.

   (c) D (rate decreases). The new molecule is a 2° alkyl iodide, which presents more steric hindrance to the nucleophile than the initial 1° alkyl iodide.

4. HO⁻. No resonance, smallest atomic radius and lowest electronegativity. Note aprotic solvent.

5. \[
\begin{array}{c}
\text{C} \\
\text{H}
\end{array}
\]

   This carbocation is 3° with resonance but has significant ring strain, and so it is not obviously more stable than the given carbocation.

6. The mostly likely rearrangement leads to the secondary carbocation that enjoys additional resonance stabilization from the oxygen lone pairs:

7. Product A. Iodide ion is a better leaving group than chloride ion.
8. 

9. This reaction does not proceed via an E1 mechanism because this would involve a primary carbocation, and primary carbocations without resonance are generally too unstable to form.

10. (a) Z. Cis/trans nomenclature does not apply to trisubstituted alkenes. R/S describes configuration at a tetrahedral atom, and does not apply to an alkene.

(b) Zaitsev’s Rule

(c) This alkene isomer has less steric strain than the given (Z) isomer.

11. 

Water is not present, so $H_3O^+$ and $H_2O$ cannot be used as reactants.

12. Although normally rare, radical combination occurs here because the concentration of oxygen in the air is much higher than normal in a radical reaction.

13. (a) Major product = molecule H. An alkyl group such as an isopropyl group is an ortho/para director. An isopropyl group provides enough steric hindrance to the incoming electrophile so that the para isomer is the major product.

(b) S (slower). Alkyl groups such as isopropyl are EAS activators.

14. (a) Yes

(b) No

15. (a)
16. **Reason #1**: Nitrogen is less electronegative than oxygen, so an amide loses more resonance stabilization than an ester upon nucleophilic attack at the carbonyl carbon.

**Reason #2**: A nitrane (R₂N⁻) is a poorer leaving group than an alkoxide (RO⁻).

17. There are many reasonable answers. For example, addition of a fluorine atom increases the magnitude of the carbonyl carbon δ⁺, resulting in more facile nucleophilic attack and faster hydrolysis:

18. (a) No
(b) Yes
(c) No

19.

20. Product I.

21.
22. The amide is protonated on the oxygen (instead of the nitrogen) because this gives a structure with better resonance.