A note about exam keys: The answers presented here may be significantly longer than expected from a student taking the exam. An exam key serves not only to reveal what was expected, but to instruct you as well.

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


(b) Anti addition of Br₂.

(c) Anti-Markovnikov addition of HBr due to peroxide effect.

(d) Friedel-Crafts alkylation. Tert-butyl group provides enough steric hindrance to favor para attack.

(e) EAS chlorination. Methyl and chlorine do not provide enough steric hindrance to overcome higher probability of ortho versus para attack.

(f) Addition of water with the reverse regiochemistry as seen with acid-catalyzed addition. Controlled mostly by steric hindrance.

(g) Acid-catalyzed addition of water via the more stable carbocation intermediate.
4. Reaction D is faster than reaction C because the rate-determining step of reaction D produces a more stable carbocation (3° with resonance) than the rate-determining step of reaction C (2°).

5. Every one of these steps are involved in steroid biosynthesis.

6. Major product = molecule E. Mechanism:

   The enols and diols are not major because they are less stable than the ketone product.

7. Only two 'yes' answers: (b) HO⁺ is not present; and (c) The pathway to molecule K involves loss of aromaticity. Even if -OH were present, it would attack the alkyne before the benzene ring.

8. In electrophilic aromatic substitution an OH group is an ortho/para director because it stabilizes an adjacent carbocation due to the OH group's lone pairs or resonance or electron donation.

9. (a) EAS bromination. The ester is an o/p director because of the lone pairs on the oxygen bonded to the benzene ring. The substituent is large enough to favor para attack.

   (b) EAS nitration. The ester is a meta director because the carbonyl electron withdrawal is more significant than its resonance stabilization of the arenium ion.

10. Reaction 9(a) is faster. When an ester is bonded to the benzene ring by the oxygen atom, the ester is an activator. When the ester is bonded to the benzene ring via its carbonyl group, the ester is a deactivator.
12. Position 4. When directing effects of substituents compete, an ortho/para director dominates over a meta director, so positions 4 and 6 are favored over positions 3 and 5. Position 4 has less steric hindrance than position 6.

13. \[
\text{Ph} \quad \text{Br}_2 \\
\text{hv} \\
\text{Ph} \quad \text{Br}
\]
Molecule M

14. \[
\text{Br} \quad \text{Br} \rightarrow 2 \text{Br}^.
\]

15. The molecule I selected in question 13 is the major product because it is a result of the more stable radical formed in the hydrogen abstraction step of the mechanism.

16. \[
\begin{align*}
\text{O}_2 & \xrightarrow{e^-} \text{Superoxide} \\
& \xrightarrow{e^-, 2\text{H}^+} \text{Hydrogen peroxide} \\
& \rightarrow 2 \text{HO}^.
\end{align*}
\]

17. \[
\text{The oxygen-oxygen bond is weakened by repulsion of adjacent lone pairs.}
\]

18. Yes: (a) CFC depletion of the ozone layer; (c) the antioxidant action of vitamin C; and (d) Viagra.