1. (21) For each reaction shown below write the major organic product in the box. Do not include any mechanism details. If no reaction occurs write "NR".

(a) \[
\text{CH}_3 \quad \text{CH}_3 \\
\text{H}_2 \quad \text{Pt} \\
\]

(b) \[
\text{Ph} \\
\text{aq. H}_2\text{SO}_4 \\
\]

(c) \[
\text{Ph} \\
1. \text{O}_3 \\
2. \text{(CH}_3)_2\text{S} \\
\]

(d) \[
\text{C(CH}_3)_3 + \\
\text{H}_3\text{C} \quad \text{Cl} \\
\text{AlCl}_3 \\
\]

(e) \[
\text{F} \\
\text{Cl}_2 \\
\text{AlCl}_3 \\
\]

(f) \[
\text{H}_3\text{C} \quad \text{CH}_3 \\
\text{Br}_2, \text{hv} \\
\]

(g) \[
\text{Br} \\
\text{HBr} \\
\text{HO}_2\text{H} \\
\]

2. (2) Write in the box the name or structure of the electrophile that adds to the pi bond in the mechanism for the reaction of question 1(g).
3. (11) Write the major organic product of the following reaction in the box. Then write the reaction mechanism in the mechanism space.

\[
\text{Ph} \quad \text{C} \equiv \text{C} \quad \text{CH}_3 \quad \overset{\text{HBr (large excess)}}{\longrightarrow}
\]

Mechanism:

4. (13) Write the major organic product of the following reaction in the box. Then write the reaction mechanism in the mechanism space.

\[
\text{Ph} \quad \text{C} \equiv \text{C} \quad \text{CH}_3 \quad \overset{\text{aq. H}_2\text{SO}_4}{\longrightarrow}
\]

Mechanism:
5. (2) Write a letter in the blank: Among reactions A, B, and C, reaction _________ is most likely (makes the most sense as written).

![Chemical structures A, B, and C](image)

6. (6) Write the mechanism for reaction A.

7. (2) Write a letter (D - F) in the blank: Among reactions D, E, and F, reaction _________ is the fastest reaction.

![Chemical structures D, E, and F](image)

8. (14) Write the major organic product of the following reaction in the box. Then write the reaction mechanism in the mechanism space. In the mechanism label the rate-determining step as rds. If any structure in mechanism has resonance, show only the most significant resonance contributor for that structure.

![Chemical structure](image)

Mechanism:
9. (3) By adding, subtracting, or changing into another element no more than four atoms of anisole (PhOCH₃), rewrite the reaction of question 8 so that it is obviously slower. Write the new reaction including starting material, reactants, and product in the space below. Do not include any mechanism details.

10. (4) Consider this reaction:

(a) Write a molecular structure in the blank. The electrophile that attacks the benzene ring is ____________.

(b) Write a letter (G - K) in the blank. The major product of this reaction is formed by attack at carbon ____.

11. (2) Write a letter (L - N) in the blank. The major product of the reaction sequence shown below is _______.

For this question, consider Br and NO₂ both to be small groups.

Questions 12 - 15 concern the biosynthesis of prostaglandin H₂ (PGH₂) by reaction of the polyunsaturated fatty acid arachidonic acid with a molecule of dioxygen (O₂) in the presence of an enzyme catalyst called cyclooxygenase:

12. (2) An early step in this process is the conversion of a cyclooxygenase amino acid side chain into a radical:

Serine

Tyrosine

Complete this statement by writing 'serine', 'tyrosine', or 'either' (if both are equally likely) in the blank: ___________________________ is most likely to be converted into the corresponding radical by this process.
13. (4) Complete this statement by adding **no more than ten words for each part**: The next step of the reaction is hydrogen atom abstraction (transfer) from site X by the radical formed in question 12. This abstraction occurs at site X instead of site Y because the product formed by abstraction from site X...

...whereas the product formed by abstraction from site Y...

14. (4) Complete this statement by writing **one word** in each blank: If the mechanism step of question 12 is a radical chain initiation, then the majority of the remaining radical chain mechanism steps are _______________ steps. Only a very tiny amount of product is formed by a radical chain step called _______________.

15. (6) The mechanism step of question 12 can also be categorized as a radical fate called atom or group transfer. In the spaces below write the names of the other two common radical fates. Using propene (H_2C=CHCH_3) and hydroxyl radical (HO) as the only reactants in each case provide an illustration of the radical fate. Include clear and precise curved arrows. If the fate can follow more than one pathway write only the most likely pathway. If the fate is unlikely, write "fate unlikely" instead of an illustration.

Radical fate #2 = ______________________________

Fate #2 illustration:

Radical fate #3 = ______________________________

Fate #3 illustration:

16. (2) Complete this statement by writing 'more', 'same', or 'less' in the blank: Dioxygen (O_2) is a _______________ reactive (or aggressive) radical than hydroxyl radical (HO).

17. (2) In the box, write the name or molecular structure of the molecule, atom, or other species that allows a small amount of a chlorofluorocarbon such as Freon-12 (CCl_2F_2) to remove a large amount of ozone from the ozone layer.