1. Draw structures for the following aromatic compounds: (12 points)

- Toluene
- \textit{m}-xylene
- Phenol
- Benzaldehyde
- 1,2-dibromobenzene
- Aniline

2. Consider the two reactions shown below. The first reaction is an addition reaction in which cyclohexene reacts with bromine to yield 1,2-dibromocyclohexane. The second reaction is a substitution reaction in which benzene reacts with bromine (with \text{AlBr}_3 catalyst) to yield bromobenzene. Compare these two reactions and explain in terms of their mechanisms how they are similar but why they lead to different types of products. It is not necessary to draw a mechanism for each reaction. (10 points)

\[ \text{Cyclohexene} + \text{Br}_2 \rightarrow \text{Cyclohexane} + \text{Br}_2 \]

\[ \text{Benzenne} + \text{Br}_2 + \text{AlBr}_3 \rightarrow \text{Bromobenzene} + \text{HBr} \]
3. When cumene (isopropylbenzene) is acylated using a Friedel-Crafts reaction, only one product is obtained (in significant amount) as shown below. (10 points)

![Diagram of the reaction]

a. Draw a step-wise mechanism for this reaction using curved arrows to show the movement of electron pairs in each step. Be sure to show how the electrophile is formed and show structures for any intermediates.

b. Briefly explain why the only product formed in significant amount is the one shown. Use steric and electronic arguments as appropriate to support your explanation. If your explanation involves electronic arguments, show resonance structures to support your explanation.
4. Starting from benzene and selecting common reagents from the set shown below, provide a synthetic reaction scheme to make 2-bromo-4-nitrocumene (shown below) in good yield. Show each of the required reactions separately and in the correct order. (6 points)

Reagents: \( \text{H}_2\text{SO}_4 \quad \text{HN}_0/\text{H}_2\text{SO}_4 \quad \text{Br}_2/\text{AlBr}_3 \quad \text{Cl}_2/\text{AlCl}_3 \quad \text{CH}_3\text{Cl}/\text{AlCl}_3 \quad \text{CH}_3\text{CHClCH}_3/\text{AlCl}_3 \quad \text{CH}_3\text{C(O)Cl}/\text{AlCl}_3 \)

![2-bromo-4-nitrocumene](image)

5. In the molecules shown below, label each stereogenic center as R or S and label each molecule as chiral or achiral. (12 points)

- ![Molecule 1](image)
- ![Molecule 2](image)
- ![Molecule 3](image)
- ![Molecule 4](image)
- ![Molecule 5](image)
6. Consider the two reactions shown below for the optically active alkyl halide, (R)-2-chloropentane. The first reaction occurs rapidly at room temperature and gives optically active product. The second reaction, starting with the same alkyl halide, occurs very slowly at room temperature and gives a non-optically active product (racemic mixture). Explain the different results in terms of the mechanism of each reaction. That is, classify each reaction in terms of its mechanism (e.g. SN1, SN2, E1, E2) and explain how each mechanism leads to the observed results. (8 points)
7. For each of the following Williamson Ether syntheses, label each with a “yes” if the reaction shown is the best way to make the ether in high yield, or “no”. For the reactions that you label “no”, write a new reaction showing the best way to make the ether. (10 points)
8. For each of the following reactions, draw the structure of the major product. If the major product is one specific stereoisomer, be sure to show the correct stereochemistry. If the major product is formed as a pair of enantiomers (racemic mixture), indicate that. It is not necessary to draw both enantiomers. (ignore the notes that say “unregistered PLT”) (3 points each = 24 points)
1.) CH₃MgBr
2.) H⁺/H₂O

(CH₃)₃C=O

H₂O

H₂O, heat

Unregistered PLT

(CH₃)₂C=CH₂

H₂O

1. ΩOH/H₂O
2. H⁺/H₂O, heat

+ CH₃COOH

(CH₃)₃C=O

H₂O

H₂O, heat
9. Starting with an appropriate aldehyde or ketone and using Grignard, alkyl lithium, or alkynide anion reagents, show a synthesis that would produce each indicated alcohol in high yield. If the reaction requires two steps, be sure to indicate both steps in proper order as 1 and 2. (8 points)