This is an open-book, open notes exam.

1. (20 points) The reactions shown would not proceed as indicated. Draw the actual products. You do not need to draw mechanisms.

   a.  \[
   \begin{array}{c}
   \text{NO}_2 \\
   \text{Br}_2 \\
   \text{FeBr}_3
   \end{array}
   \rightarrow
   \begin{array}{c}
   \text{NO}_2 \\
   \text{Br}
   \end{array}
   \]

   b.  \[
   \begin{array}{c}
   \text{NH}_2 \\
   \text{1. NaNO}_2 \\
   \text{HCl} \\
   \text{2. CuBr}_{\text{CO}_2\text{Et}}
   \end{array}
   \rightarrow
   \begin{array}{c}
   \text{CN}
   \end{array}
   \]

   c.  \[
   \begin{array}{c}
   \text{N}_2 \\
   \text{Cu cat}
   \end{array}
   \rightarrow
   \begin{array}{c}
   \text{CO}_2\text{Et}
   \end{array}
   \]

   d.  \[
   \begin{array}{c}
   \text{CO}_2\text{CH}_3 \\
   \text{NaH x 2}
   \end{array}
   \rightarrow
   \begin{array}{c}
   \text{CO}_2\text{CH}_3
   \end{array}
   \]

2. (20 points) Circle the expected product. Explain your answer in detail. Stereochemistry is important!
3. (20 points) Outline a synthesis of **A** using only starting materials that contribute three or fewer carbons to the final product.

![Chemical structure of A](image)

4. (20 points) Deduce the structure of **C** and draw an arrow-pushing mechanism for its formation.

![Chemical structure of B and C](image)

**C**::<br>

\[
\text{C}_{10}\text{H}_{12}\text{O}_2
\]

**\(^1\)H NMR:**
- 1.95, m, 1H
- 2.15, m, 1H
- 2.60, dd, J = 2.5, 6.0 Hz, 1H
- 2.89, dd, J = 4.0, 6.0 Hz, 1H
- 3.20, ddt, J = 2.5, 4.0, 7.0 Hz, 1H
- 4.18, t, J = 7.4 Hz, 2H
- 6.95, m, 3H
- 7.38, m, 2H

**\(^13\)C NMR:**
- 158.7, s
- 129.5, d
- 120.9, d
- 114.5, d
- 64.5, t
- 49.8, d
- 47.2, t
- 32.5, t

5. (20 points) Draw the letters on the product where they belong. Make a list of bonds formed and bonds broken, and draw the mechanism in detail.

![Chemical structure of product with letters](image)