1. Consider the reaction energy diagram shown below:

![Reaction Energy Diagram](image-url)

a) How many steps does this reaction have?
b) How many transition states are there?
c) How many intermediates are there? Which species, A, B, C, or D, is/are intermediate(s)?
d) Which intermediate is more stable?
e) Which is the rate-determining step?
f) Is the first step exergonic or endergonic?
g) Is the overall reaction exergonic or endergonic?
h) Is it possible to write a rate law for this reaction with the information given? Explain your answer.

2. Some of the following examples can show geometric isomerism, and some cannot. For the ones that can, draw all geometric isomers and assign complete names using E-Z system.

(a) 3-bromo-2-chloro-2-pentene
(b) 3-ethyl-2,4-hexadiene
(c) 3-bromo-2-methyl-2-butene
(d) 1,3-pentadiene
(e) 4-tert-butyl-5-methyl-4-octene
3. Polar reactions usually involve the formation of a new sigma bond. There are a number of ways for this to happen.

   a) A cation can encounter an anion.

      \[
      \begin{array}{c}
      \text{A}^+ \\
      \text{B}^-
      \end{array} \rightarrow \text{AB}
      \]

   b) A cation can encounter a neutral nucleophile.

      \[
      \begin{array}{c}
      \text{A}^+ \\
      \text{B}
      \end{array} \rightarrow \text{AB}
      \]

   c) A charged nucleophile can encounter a neutral molecule with an electron poor atom which is attached to a leaving group.

      \[
      \begin{array}{c}
      \text{B}^-
      \end{array} \rightarrow \begin{array}{c}
      \text{C}^-
      \end{array} + \begin{array}{c}
      \text{LG}^-
      \end{array}
      \]

Based on the above examples, complete the following equations. Be sure to use curved arrow formalism to indicate electron flow.

\[
\begin{align*}
\text{C}^+ \text{CH}_3 & \rightarrow \text{O}^\ominus \text{C} \text{CH}_3 \\
\text{H} \text{C}^\ominus \text{CH}_3 & + \text{N}^\ominus (\text{CH}_3)_3 \\
\text{HO}^\ominus & + \text{CH}_2\text{Br} \\
\text{S}^\ominus \text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} &
\end{align*}
\]
4. Complete the following mechanisms by adding the arrows which indicate flow of electrons.

\[ \text{H}_3\text{C} - \text{C} - \text{OCH}_2\text{CH}_3 \quad \rightarrow \quad \text{H}_3\text{C} - \text{C} - \text{NH}_2 + \text{CH}_3\text{CH}_2\text{O}^- \]

\[ \bigcirc + \text{CN}^- \quad \rightarrow \quad \text{O} - \text{CH}_2\text{CH}_2\text{CN} \]

\[ \text{H}_3\text{C} - \begin{array}{c} \text{O}^- \\ \text{CH}_3 \end{array} - \begin{array}{c} \text{C} \\ \text{CH}_3 \end{array} - \begin{array}{c} \text{O}^- \\ \text{H} \end{array} \quad \rightarrow \quad \text{H}_3\text{C} - \begin{array}{c} \text{O}^- \\ \text{CH}_3 \end{array} + \text{HO} - \begin{array}{c} \text{C} \\ \text{C} \end{array} - \begin{array}{c} \text{OH} \\ \text{C} \end{array} \]

\[ \text{CN} - \bigcirc - \begin{array}{c} \text{C} \\ \text{CN} \end{array} - \text{OH} \quad \rightarrow \quad \text{C} - \begin{array}{c} \text{C} \\ \text{CN} \end{array} + \text{CN}^+ \]