1. Label the allylic and vinylic hydrogens in the following molecules.

(a) ![Chemical Structure](image1)  
(b) ![Chemical Structure](image2)  
(c) ![Chemical Structure](image3)

2. Write a second resonance structure for the following. Is the charge shared equally by both allylic carbons? If not, which one bears more charge?

(a) ![Chemical Structure](image4)  
(b) ![Chemical Structure](image5)  
(c) ![Chemical Structure](image6)

3. Draw resonance structures of the following.

(a) ![Chemical Structure](image7)  (1 other structure)  
(b) ![Chemical Structure](image8)  (2 other structures)  
(c) ![Chemical Structure](image9)  (2 other structures)  
(d) ![Chemical Structure](image10)  (1 other structure)  
(e) ![Chemical Structure](image11)  (3 other structures)
4. In Problem 3 a-d above, rate the different resonance structures in each group in order of relative quality. That is, which would be the most important contributor to the hybrid? The least? Justify your answer.

5. From the following compounds, choose the two that yield the same carbocation upon ionization.

6. Show the products of the following reactions. Are the products in (a) and (b) the same molecule or different molecules? How about (c) and (d)?

(a) \[ \text{ } + \ 1 \text{ HCl} \quad \text{(from 1,2-addition)} \]

(b) \[ \text{ } + \ 1 \text{ HCl} \quad \text{(from 1,4-addition)} \]

(c) \[ \text{ } + \ 1 \text{ Br}_2 \quad \text{(from 1,2-addition)} \]

(d) \[ \text{ } + \ 1 \text{ Br}_2 \quad \text{(from 1,4-addition)} \]
7. Show the products of the following reactions. More than 1 product may be possible. To answer this properly, you will most likely need to consider the mechanism carefully (see the next problem).

(a) \[ \text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_3 + \text{Cl}_2 \xrightarrow{\text{light}} \]

(b) \[ \text{CH}_3 \xrightarrow{\text{NBS}} \]

(c) \[ \text{Br} \xrightarrow{\text{KOEt, EtOH}} \]

(d) \[ \text{CH}_3\text{CHCH}=\text{CH}_2 \xrightarrow{\text{H}_2\text{SO}_4, \text{heat}} \]

(e) \[ \text{+ 1 Br}_2 \]

(f) \[ \text{+ 1 HCl} \]

(g) \[ \text{CH}_3\text{CH}=\text{CHCH}_2\text{OH} + \text{HCl} \]

(h) \[ \text{CH}_2=\text{CH-CH}=\text{CH}_2 + \text{1 HBr} \xrightarrow{\text{ROOR}} \]

8. Show the mechanism to justify your answers in Problem 7.
9. Show how to carry out the following syntheses, using any needed organic and inorganic reagents. Some may require several steps.

(a) \( \text{Br} \quad \text{from} \quad \text{Br} \)

(b) \( \text{CH}_3 \text{CHBrBr} \quad \text{from} \quad \text{CH}_3 \text{CH} = \text{CH}_2 \)

(c) \( \text{Br} \quad \text{from} \quad \text{Br} \quad \text{from} \quad \text{CH}_2 = \text{CH}_2 \)

(d) \( \text{HO} \quad \text{from} \quad \text{CH}_2 = \text{CH}_2 \)

(e) \( \text{Br} \quad \text{from} \quad \text{CH}_2 = \text{CH}_2 \)

(f) \( \text{HO} \quad \text{from} \quad \text{C}_5 \text{H}_{10} \)

(g) \( \text{I} \quad \text{from} \quad \text{C}_5 \text{H}_{10} \)

(h) \( \text{NC} \quad \text{from} \quad \text{C}_5 \text{H}_{10} \)

(i) \( \text{C}_5 \text{H}_{10} \quad \text{from} \quad \text{C}_5 \text{H}_{10} \)

(j) \( \text{C}_5 \text{H}_{10} \quad \text{from} \quad \text{C}_5 \text{H}_{10} \)

10. Show the two possible products of 1,2-addition of HCl to 2-methyl-1,3-butadiene. Their formation is temperature dependent. Which one would be favored at lower temperature and which one would be favored at higher temperature? Why?
11. Explain the following in terms of kinetic and thermodynamic control. You will need to draw a potential energy diagram to fully complete your answer.

\[
\begin{align*}
&\text{CH}_3\text{Br} + \text{HBr} \xrightarrow{\text{higher temp.}} \text{major} + \text{minor} \\
&\text{lower temp.} \quad \text{raise temp. to higher temp.}
\end{align*}
\]

12. Show the product and appropriate stereochemistry of the following Diels-Alder reactions.

(a) 
\[
\begin{align*}
\text{H}_2\text{C} = \text{CH}_2 + \text{C}_2\text{H}_4\text{O} \rightarrow \\
\text{products}
\end{align*}
\]

(b) 
\[
\begin{align*}
\text{H}_2\text{C} = \text{CH}_2 + \text{C}_6\text{H}_5\text{CO}_2\text{Et} \rightarrow \\
\text{products}
\end{align*}
\]
13. Show the reagents (diene and dienophile) that would yield the following Diels-Alder adducts.

(a)

(b)

(c)

(d)