Answer all the questions.

1) Draw Lewis structures (lines for bonds and dots for all lone pairs) for the following molecules: (5pts)

(a) \( \text{NF}_3 \)  
(b) \( \text{HCO}_2\text{H} \)

2) (16pts): For the below molecule, calculate the number of...

- a) carbon atoms
- b) hydrogen atoms
- c) oxygen atoms
- d) Bromine atoms
- e) \( sp^2 \) hybridized carbons
- f) \( sp^2 \) hybridized atoms
- g) \( sp^3 \) hybridized atoms
- h) lone pairs (non bonding pairs) of electrons.
3) (8pts) (i) What is meant by the term *Mechanism*?

(ii) What is meant by *Structural Isomer*?

(iii) What is the *Hammond Postulate*?

(iv) What is *Entropy*?

4) For the following pairs of compounds, state whether they are the DIFFERENT, SAME, STEREOISOMERS or STRUCTURAL ISOMERS. (12pts)

(a) \[ \begin{array}{c}
\text{Br} \\
\text{H} \\
\text{H} \\
\end{array} \quad \begin{array}{c}
\text{Br} \\
\text{H} \\
\text{H} \\
\end{array} \quad \begin{array}{c}
\text{Br} \\
\text{H} \\
\text{Br} \\
\end{array} \quad \begin{array}{c}
\text{Br} \\
\text{H} \\
\text{H} \\
\end{array} \]

(b) \[ \begin{array}{c}
\text{Br} \\
\text{H} \\
\text{Br} \\
\end{array} \quad \begin{array}{c}
\text{Br} \\
\text{H} \\
\text{H} \\
\end{array} \]

(c) \[ \begin{array}{c}
\text{F} \\
\text{Br} \\
\text{H} \\
\end{array} \quad \begin{array}{c}
\text{Cl} \\
\text{F} \\
\text{H} \\
\end{array} \]

(d) \[ \begin{array}{c}
\text{Br} \\
\text{CH}_3 \\
\text{H} \\
\end{array} \quad \begin{array}{c}
\text{H} \\
\text{CH}_3 \\
\text{Br} \\
\end{array} \]

(e) \[ \begin{array}{c}
\text{F} \\
\text{CH}_3 \\
\text{H} \\
\end{array} \quad \begin{array}{c}
\text{H} \\
\text{F} \\
\text{CH}_3 \\
\end{array} \]

(f) \[ \begin{array}{c}
\text{Br} \\
\text{Br} \\
\text{F} \\
\end{array} \quad \begin{array}{c}
\text{Br} \\
\text{F} \\
\text{Br} \\
\end{array} \]
5) (12pts): For the below energy level diagram...

a) is this reaction exothermic or endothermic?

b) would this reaction have an Equilibrium constant (K) greater or less than 1.00?

c) how many transition states are there?

d) how many steps is this multistep reaction?

e) which step is the rate determining step?

f) which is the fastest step?

6) Using Newman projections (looking along C1 and C2), draw any two different conformations of 1,2-dichloroethane, ClCH₂CH₂Cl, and indicate which of the two you have drawn would have the lower energy. (8pts)
7) Name the following compounds in IUPAC form. (15pts)

(a) 

(b) 

(c) 

(d) 

(e)
8) Circle the more stable member of each pair. (6pts)

(a) 

(b) 

(c) 

9) In the lowest energy conformation of cis-1,3-dimethylcyclohexane, how many axial positions are occupied by Hydrogen atoms? (4pts)

10) Besides the chair conformation, name two other conformations of a cyclohexane ring. (2pts)
11) Predict the geometry of the methyl radical, •CH₃ (you should mention the hybridization, shape and bond angles for full points. (7pts)

12) Dibromocyclobutane is a vague chemical name that can describe many different organic structures. Draw 5 different compounds that fit the description of dibromocyclobutane. (5pts)
If you do not want your graded exam placed in the box outside my office, then please check here_____

Answer all the questions.

1) Draw Lewis structures (lines for bonds and dots for all lone pairs) for the following molecules: (5pts)

(a) $\text{NF}_3$

(b) $\text{HCO}_2\text{H}$

2) (16pts): For the below molecule, calculate the number of...

- a) carbon atoms: 15
- b) hydrogen atoms: 12
- c) oxygen atoms: 4
- d) Bromine atoms: 0
- e) $sp^2$ hybridized carbons: 13
- f) $sp^2$ hybridized atoms: 14
- g) $sp^3$ hybridized atoms: 9
- h) lone pairs (non bonding pairs) of electrons: 18
3) (8pts) (i) What is meant by the term Mechanism?
Step by step movement of electrons explaining bond formation & bond breaking during a chemical reaction

(ii) What is meant by Structural Isomer?
Compounds that are different but have the same molecular formula and differ in their bond connectivity.

(iii) What is the Hammond Postulate?
In related chemical processes, species that are similar in energy will be similar in structure.

(iv) What is Entropy?
Randomness, disorder.

4) For the following pairs of compounds, state whether they are the DIFFERENT, SAME, STEREOISOMERS or STRUCTURAL ISOMERS. (12pts)

(a) \[\text{Br} \quad \text{Br} \quad \text{Br} \quad \text{Br} \]
\[\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \]
\text{Stereoisomers}

(b) \[\text{Br} \quad \text{H} \quad \text{Br} \quad \text{H} \]
\[\text{H} \quad \text{Br} \quad \text{H} \quad \text{Br} \]
\text{Structural Isomers}

(c) \[\text{F} \quad \text{Br} \quad \text{Cl} \quad \text{F} \]
\[\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \]
\text{Different}

(d) \[\text{Br} \quad \text{CH}_3 \quad \text{Br} \quad \text{CH}_3 \]
\[\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \]
\text{Same}

(e) \[\text{F} \quad \text{CH}_3 \quad \text{H} \quad \text{F} \]
\[\text{H} \quad \text{H} \quad \text{H} \quad \text{CH}_3 \]
\text{Structural Isomers}

(f) \[\text{Br} \quad \text{Br} \quad \text{Br} \quad \text{Br} \]
\[\text{Br} \quad \text{F} \quad \text{Br} \quad \text{F} \]
\text{Same}
5) (12pts): For the below energy level diagram...

![Energy Level Diagram]

a) is this reaction exothermic or endothermic? **EXOTHERMIC**

b) would this reaction have an Equilibrium constant (K) greater or less than 1.00? **K > 1**

c) how many transition states are there? **4**

d) how many steps is this multistep reaction? **4**

e) which step is the rate determining step? **2nd**

f) which is the fastest step? **4th**

6) Using Newman projections (looking along C1 and C2), draw any two different conformations of 1,2-dichloroethane, ClCH$_2$CH$_2$Cl, and indicate which of the two you have drawn would have the lower energy. (8pts)

![Newman Projections]
7) Name the following compounds in IUPAC form. (15pts)

(a) [structure] \[\text{Hexane}\]

(b) [structure] \[\text{trans-1,2-diethylcyclopentane}\]

(c) [structure] \[\text{2-Methylpentane}\]

(d) [structure] \[\text{2,3-trimethylpentane}\]

(e) [structure] \[\text{2,3-dimethylbutane}\]
8) Circle the more stable member of each pair, (6pts)

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

(b) \[ \text{Br} \quad \text{Br} \quad \text{H} \quad \text{F} \quad \text{H} \]

(c) \[ \text{Br} \quad \text{CH}_3 \quad \text{Br} \quad \text{CH}_3 \]

9) In the lowest energy conformation of cis-1,3-dimethylcyclohexane, how many axial positions are occupied by Hydrogen atoms? (4pts)

Chair conformation, 2 axial methyls in equatorial.

6 axial hydrogens.

10) Besides the chair conformation, name two other conformations of a cyclohexane ring. (2pts)

Boot, half chair, twist boat
11) Predict the geometry of the methyl radical, •CH₃ (you should mention the hybridization, shape and bond angles for full points. (7pts)

\[
\begin{align*}
\text{H-\textbullet C-H} & \text{ has 3 \sigma bonds, zero lp} \\
\Rightarrow & \text{ } \text{Sp}^2 \text{ hybridization for C.}
\end{align*}
\]

The •CH₃ is trigonal planar, with H-C-H bond angles of 120°. The radical electron is in the unhybridized p orbital.

12) Dibromocyclobutane is a vague chemical name that can describe many different organic structures. Draw 5 different compounds that fit the description of dibromocyclobutane. (5pts)

\[
\begin{align*}
\text{Br} & \text{ Br} \\
\text{Br} & \text{ Br} \\
\text{Br} & \text{ Br} \\
\text{Br} & \text{ Br} \\
\text{Br} & \text{ Br}
\end{align*}
\]