Question 1 (12 pts.) Give the IUPAC name for the following structure.

```
Br
  1
  
  2
  
  3
  
  4
  
  5
  
  6

2-bromo-5,5-dimethyl-3-propyl-(2E)-hexene
```

Question 2 (35 pts.)

a) Give a full curved-arrow pushing mechanism for the following reaction, indicate the Lewis acid/base and Bronsted acid/base at each step as appropriate. Indicate the rate determining step in your mechanism. CLASSIFY THE REACTION as addition, elimination, substitution or rearrangement. GIVE THE NUMBER of transition states and sets of intermediates in your mechanism.

```
H Br
  LA/BA

H Br
  LB/BB

HBr
  CCl_4 (inert solvent)

RDS

:Br:

H

:Br:

LA

LB

ADDITION
3 transition states
2 sets of intermediates
```

b) Draw a reaction energy diagram with properly labelled axes for the reaction above. Draw on the diagram the activation energy for EVERY STEP of the mechanism, and clearly indicate which one is the rate determining step. Also draw on the diagram the overall reaction exothermicity or endothermicity. Indicate the positions of the transition states (but do not draw them).

```
Energy

RDS

E_a^1

E_a^2

E_a^3

H Br

exothermicity

Br H

Reaction Coordinate
```
Question 3 (28 pts.) For the TWO Lewis acid base reactions shown below:  
a) add the curved arrow pushing that describes bond breaking/making, **redraw the HBr as a Lewis structure so that you can do the proper curved-arrow pushing**, indicate the Lewis acid/base and whether they are also Bronsted acids/bases
b) add any important additional resonance contributors for the cations that are missing on the product side of the equation, with resonance arrows/brackets as appropriate
c) state whether each reaction would be exothermic or endothermic and **give a brief explanation**

![Reaction Diagram](image)

both reactions are ENDOTHERMIC. both break 2 bonds (sigma and pi) and both only make one sigma bond

d) draw a reaction energy diagram for these two reactions ON THE SAME DIAGRAM (do not draw 2 diagrams), clearly indicate which diagram refers to which reaction, **include the activation energies for both reactions and indicate the POSITIONS of the transition states**
e) indicate which would be faster, reaction A or B and give a BRIEF explanation for your choice that includes the term "Hammond postulate".

![Reaction Energy Diagram](image)

reaction A is faster, both form a resonance stabilized cation but the cation in A is more stable since one of the resonance contributors has a 3° cation center, the Hammond postulate says that the less endothermic reaction has the smaller activation energy, the faster rate and the earlier transition state
Question 4 (40 pts.) Give the missing major organic products OR reagents/conditions as appropriate for each of the following reactions (include all non-bonding electrons when drawing the products).

*clearly indicate, using wedged/dashed bonds, the relative sterochemistry in the products WHERE RELEVANT*

*state whether each reaction is addition, substitution, elimination or rearrangement*

(a) \[
\begin{align*}
&\text{(a)} & \text{HCl (cat.)} & \text{H}_2\text{O (solvent)} \\
& & & \\
& & & \text{addition}
\end{align*}
\]

(b) \[
\begin{align*}
&\text{(b)} & 1. \text{Hg(OAc)}_2/\text{CH}_3\text{OH} & 2. \text{NaBH}_4 \\
& & & \\
& & & \text{addition}
\end{align*}
\]

(c) \[
\begin{align*}
&\text{(c)} & \text{NBS} & \text{hv} \\
& & & \\
& & & \text{substitution}
\end{align*}
\]

(d) \[
\begin{align*}
&\text{(d)} & \text{Br}_2 & \text{EtOH} \\
& & & \\
& & & \text{or}
\end{align*}
\]

(e) \[
\begin{align*}
&\text{(e)} & 1. \text{BH}_3/\text{THF} & 2. \text{-OH/H}_2\text{O}_2 \\
& & & \\
& & & \text{H}
\end{align*}
\]
Question 5 (30pts.) For the following Bronsted acid/base equilibrium (not all of the H atoms are specifically shown in the line-angle structures):

a) Draw the curved arrows for reaction in both directions

b) Add any missing important resonance contributors for the anions on both sides of the equilibrium

c) Identify the stronger acid and base on each side, indicate which acid would have the smaller pKa, indicate which reaction would be faster and give a brief explanation for your choices

d) Indicate on which side the equilibrium would lie

Although both anions are resonance stabilized, the weaker base anion delocalizes the negative charge onto the more electronegative oxygen, lowering the electron energy, reducing the chemical reactivity of the electrons, the base is easier to make and thus has the stronger conjugate acid.

e) Draw an energy diagram with properly labelled axes for the equilibrium shown above, showing the activation energy in BOTH directions and draw the transition state.
Question 6 (30 pts)
a) Provide a curved arrow-pushing mechanism for the following reaction, indicate the Lewis acid/base at each step and whether they are also Bronsted acids/bases.
b) Give a drawing of the transition state for the RATE DETERMINING STEP ONLY and indicate the rate determining step on your mechanism and give a brief (one sentence) explanation for your choice of rate determining step.
c) State whether the reaction is overall exothermic or endothermic, briefly explain your reasoning.

the rate determining step is the slowest step because it is the most endothermic step because it is the only step that breaks more bonds than it makes.

the reaction is overall exothermic because one sigma bond and one pi-bond are converted into two sigma-bonds.

Extra Credit (5 pts) Extremely strong Bronsted acids made by mixing fluorosulfonic acid and antimony pentafluoride are called super acids, mega acids, big bang acids, and magic acids.