Question 1

Which of the following is the strongest Bronsted Acid? R-CO₂H is a carboxylic acid and R-SO₃H is a sulfonic acid, you will want to draw these two as Lewis structures and also draw the conjugate base anions to answer this question.

The strongest acid has the most stable conjugate base anion.

More acidic, lower pKa → H₂O → H₃O⁺ + A⁻ → more stable.

Less acidic, higher pKa → H₂O → H₃O⁺ + B⁻ → less stable.

Bronsted acidity is controlled by the following factors:
1. Electronegativity of the atom with the negative charge.
2. The size of the atom bearing the negative charge.
3. Resonance.
4. Substituent effects.

Increasing Stability

The remaining difference is the substituents. The electron withdrawing CF₃ group (3 electronegative F’s) stabilizes the negative charge and thus the anion. Later we will see that a resonance electron donating group such as -OCH₃ destabilizes the negative charge and thus the anion.
Question 2

Which of the following statements about the equilibrium below is true?

<table>
<thead>
<tr>
<th>Stronger Acid</th>
<th>Stronger Base</th>
<th>Weaker Base</th>
<th>Weaker Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetone</td>
<td>allyl anion</td>
<td>propene enolate</td>
<td>acetone</td>
</tr>
<tr>
<td>pK\textsubscript{a} = 19</td>
<td></td>
<td></td>
<td>pK\textsubscript{a} = 43</td>
</tr>
</tbody>
</table>

I  the equilibrium will lie on the left
II  the equilibrium will lie on the right
III  the allyl anion is the strongest base in the equilibrium
IV  propene is the weakest acid in the equilibrium

A  I and IV only  
B  II and IV only  
C  II, III and IV only  
D  I, III and IV only

acetone and propene are the acids on each side of the equilibrium, the two anions are the bases. The strongest acid is the one with the lower pK\textsubscript{a}

the stronger acid has the weaker conjugate base and vica versa, thus the allyl anion is the strongest base. The strongest acid and the strongest base "push" the equilibrium to the RIGHT because they react faster than the weaker acid and base react in the reverse direction

both of these answers are easy to obtain since the pK\textsubscript{a}'s are given, the smaller pK\textsubscript{a} corresponds to the stronger acid

you could also have worked this out based on electron energies. Acetone is the stronger acid because it "makes" the more stable conjugate base, acetone enolate. Comparing resonance structures of the two anions, the negative charge is "shared" by two carbons in the allyl anion, but by a carbon and a more electronegative oxygen in the enolate, the electrons are lower in energy in the enolate, the enolate is less reactive, is a weaker base.
**Question 3**

MC20d

Which of the following is the product of the acid/base reaction between aluminum trichloride ($\text{AlCl}_3$) and acetone ($\text{CH}_3\text{COCH}_3$)?

Although $\text{AlCl}_3$ has lots of non-bonding electrons, they are on the electronegative chlorines and are thus not very high in energy, not very reactive. The non-bonding electrons on acetone are also on an electronegative atom, oxygen, and whether acetone reacts as a base or an acid depends upon what it reacts with.

In this case the key point is that aluminum has only 3 valence electrons, thus with 3 bonds to chlorine it can easily accept a pair of electrons from oxygen, thus forming a bond without having to break a bond, this is an ideal Lewis acid/base reaction. Note that if the pi-electrons in the acetone had been used, a bond would have been broken in the reaction, thus D is not a good answer.

The oxygen will develop a formal positive charge since it loses a half share of the non-bonding electrons, and the aluminum gains a formal negative charge since it gains a half share of the non-bonding pair.

The electrons in the new bond are considerably lowered in energy, we expect this Lewis acid/base reaction to be exothermic.
Question 4
MC20e

Give the major product of the following Lewis Acid/Base reaction. Note that the non-bonding electrons are NOT shown on the fluorines in either the reactants or products (hint, you will need to draw a minor resonance contributor of the ester to determine the most reactive pair of non-bonding electrons in the ester).

B and D are impossible, boron does not have a pair of electrons that it can use to form a new bond.

To decide between A and C, consider the following minor resonance contributor:

[\begin{array}{c}
\text{LB} \\
\text{LA}
\end{array}]

OR, consider the following bond dipole moments:

A is bigger than C because of the pi electrons in the double bond.

Either way it is clear that there is a larger partial negative charge on the carbonyl (C=O) oxygen, thus the electron energy will be higher on this oxygen, hence these electrons are more reactive, these represent the Lewis base site.
Question 5
MC20i

Which of the following reactions is most likely to occur?

A makes a σ-bond, breaks a π-bond and puts negative charge on oxygen, this is the best.

B gives electrons to hydride, nowhere for them to go, very bad reaction!

C makes a σ-bond, breaks a π-bond and puts negative charge on carbon, which is not as good as A.

D gives electrons to hydride, nowhere for them to go, very bad reaction!
Question 6
MC20k

Which is the most acidic proton in this molecule, Ha, Hb, Hc or Hd (not all of the C-H bonds are shown in this molecule)? hint, draw all of the conjugate base anions

A Ha
B Hb
C Hc
D Hd

THREE resonance contributors for the anion structure, most delocalized lowest energy non-bonding electrons, most stable conjugate base anion, most acidic proton
Question 7
MC201
Which is the weakest base? (hint, look for minor resonance contributors)

A

no minor resonance contributors to the structure, non-bonding electrons are not particularly stabilized or low in energy

B

no minor resonance contributors to the structure, non-bonding electrons are not particularly stabilized or low in energy

C

minor resonance contributor to the structure shows how the non-bonding electrons are somewhat stabilized by delocalization, and this lower in energy than in A or B

D

two minor resonance contributors to the structure shows how the non-bonding electrons are even more stabilized by delocalization than in C, these non-bonding electrons are thus lowest in energy of all, are thus least reactive, D is thus the weakest base