1. (8 pts) Indicate the oxidation number of the highlighted C atoms in each of the following molecules.

a) ![Chemical structure](image)

b) ![Chemical structure](image)

c) ![Chemical structure](image)

d) ![Chemical structure](image)
2. (20 pts) **Provide the conjugate acid and conjugate base** from each of the following acid-base reactions. Then give the acids on each side of the equations **approximate pKa values** and indicate in each case if you expect the equilibrium constant, $K$, to be $>1$, $<1$, or $\sim 1$.

a)

\[
\text{H}_3\text{O}^+ + \text{Li}^- \rightarrow \text{H}_2\text{O} + \text{Li}^+ \quad \text{pKa} \approx 36
\]

b)

\[
\text{PhOH} + \text{KN(CH}_3\text{)_2} \rightarrow \text{PhOK} + \text{HN(CH}_3\text{)_2} \quad \text{pKa} \approx 16
\]

c)

\[
\text{CH}_3\text{-C}≡\text{C-Li} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{-C}≡\text{C-H} + \text{LiOH} \quad \text{pKa} \approx 16
\]

d)

\[
\text{Ph-OH} + \text{OCs} \rightarrow \text{PhOOCs} + \text{OH}^- \quad \text{pKa} \approx 5
\]

e)

\[
\text{ONa} + \text{H}_3\text{O}^- \rightarrow \text{OH}^- + \text{Na}^+ \quad \text{pKa} \approx -1.7
\]
3. (15 pts) **Provide acceptable names** for the following molecules. Trivial or IUPAC names may be used as appropriate.

a)  
![Chemical structure](image)  
6,6-difluoro-5-methyloct-4-ol

b)  
![Chemical structure](image)  
cis-3-isopropylcyclopentanol

c)  
![Chemical structure](image)  
bicyclo[4.2.2]decane

d)  
![Chemical structure](image)  
3-bromo-4-chloro-5,8,8-trimethylundecane

e)  
![Chemical structure](image)  
5-ethyl-3,3-dimethylcyclohexanol
4. (9 pts) **Provide structures** that correspond to the desired conformation in the following situations:

   a) Newman projection of the **anti conformation** of 2,7-dimethyloctane along the C-4 – C-5 bond axis.

   ![Image](image1.png)

   b) Newman projection of a **gauche** conformation of 1,1,-dibromoheptane along the C-3 – C-4 bond axis.

   ![Image](image2.png)

   c) Newman projection of the **least stable conformation** of butane along the C-2 – C-3 bond axis.

   ![Image](image3.png)

5. (6 pts) **Label the approximate shapes** of the indicated atoms within the following molecules.

   a) ![Image](image4.png)

   b) ![Image](image5.png)
6. (9 pts) **Draw acceptable structures** for each of the following molecules.

   a) cis-4-t-Butylcycloheptanol

   ![Structure of cis-4-t-Butylcycloheptanol](image)

   b) 3,3-Difluoro-4,4-dimethyl-1-heptanol

   ![Structure of 3,3-Difluoro-4,4-dimethyl-1-heptanol](image)

   c) Bicyclo[4.2.0]octane

   ![Structure of Bicyclo[4.2.0]octane](image)

7. (6 pts) Using curved arrows, show a **complete mechanism** for how the following conversion takes place. On your diagram, **circle the structure** that corresponds to the **reactive intermediate** that is formed.

   ![Mechanism Diagram](image)
8. (8 pts) For the **highlighted** atom in the following molecules, complete its atomic electron configuration on the left, and then draw a picture on the right of the **hybridization model** that would best explain the orbitals used for bonding by the **highlighted** atoms.

![O=C=O Energy hybridize sp](image)

![Energy hybridize sp^2](image)

9. (6 pts) Even though the following molecules do not differ much in their relative molecular weights they differ dramatically in terms of their boiling points (given below each structure). **Explain.**

![alkane -42°C](image)

![F -32°C](image)

![OH 78°C](image)

The alkane is very non-polar and has no dipole, therefore the intermolecular attractions between molecules are weak and easy to break, hence the very low boiling point. The alkyl fluoride has a dipole so molecules have increased electrostatic attraction which holds them together somewhat tighter, and which take more energy to break, thus resulting in a higher boiling point. The alcohol has both dipolar attractions as well as hydrogen bonds between molecules; therefore the boiling point is significantly higher since these attractions require much more energy to break.
10. (6 pts) For the following compounds, give approximate pKa values for each, and then explanations for why there is such a difference in values even though the acidic proton is bonded to oxygen in each case.

![Chemical structures](image)

Since the proton is on O in each case, the acidity of these molecules is based mainly on the relative stability of the conjugate bases (shown above). The alcohol will produce a conjugate base in which the charge is localized and so not particularly stable. Phenol (b) will give an anion that is stabilized by delocalization of the charge through the pi bond system and so therefore much more stable than in (a); the OH group is more acidic as a result. The alkoxonium ion in (c) produces a neutral, stable molecule as its conjugate base.

11. (7 pts) For cis-1,3-dibromocyclohexane and trans-1,3-dibromocyclohexane, draw the most stable and least stable chair conformations, then decide which isomer of the two is more stable. Explain your choices in terms of the steric interactions that both isomers will experience.

![Chemical structures](image)

The cis-1,3-isomer is more stable since both of the large Br atoms are able to be in equatorial positions. The ring-flipped trans-1,3-isomer will always have a Br atom in an axial position which will cause destabilizing 1,3-diaxial interactions (below).