Name: \_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_

Organic Chemistry Practice Exam 1 Answer Key

Questions 1-10: Name the following organic compounds according to IUPAC nomenclature

1. 6-chloro-1-ethyl-1-cyclohexene
2. (1Z)-1-ethyl-4-methylcycloheptane
3.  (1R, 2S)-1,2-dichlorocyclopropane
4. (8R)-8-chloro-5-ethyltetradecane
5.  5-(4-bromocyclohexyl)-7,7-dimethyl-1,10-undecadiene
6.  pentan-4-amino-2-ol
7. 6-amino-1-methoxynon-8-en-3-ol
8. (2R, 5S, 6R)-6-cyclopropyl-5-methylheptan-2-ol
9. 2-bromo-4-ethoxycyclopentan-1-ol
10. (1E)-1-methoxy-2-methylbutan-1-ene

Questions 11-20: Determine the stereochemistry and/or stereochemical relationship of each chiral compound(s) (if applicable)

1. from top to bottom: Left: S, R Right: S, S, therefore they are diastereomers
2.  from front to back: left: S, R right: R, S therefore they are enantiomers.
3. Left: S, R (previously solved problem) right: S, S (previously solved problem) therefore they are diastereomers
4.  Left: R, S Right: S, R. They are enantiomers, however, because this is a meso compound they are actually identical because there is a plane of symmetry in the molecule when the two OH groups are cis to one another.
5.  Left: R, S Right: S, R. They are enantiomers. Notice how the extra methyl group breaks the plane of symmetry and therefore this is no longer a meso compound.
6. Left: S, R Right: R,R These are completely different compounds, the one on the right has a methoxy group on the back carbon while the other compound does not.
7. Left: S, R (previously solved problem) Right: S, R. They also have the same groups on both chiral carbons, therefore they are IDENTICAL! An easier way to see this is to notice that for the front carbon, the groups are all shifted over one unit clockwise and for the back carbon, the same applies.
8. Left: S,R (previously solved problem) Right: R, S. Because they have the same groups on both chiral carbons but opposite configurations, they are enantiomers. Notice that in comparing the left and right, the groups are simply shifted over one spot for both top and bottom carbons. Whenever an odd number of shifts occurs, the configurations is inverted and whenever an even number of shifts occurs, configuration is retained.
9.  No carbon in either compound is chiral. They both have the same groups on all carbons and therefore they are identical.
10. Same as above, no carbon is chiral therefore they are both the same because they have the same groups on all carbons.

Questions 21-30: Determine which direction the equilibrium would lie in these acid-base chemistry reactions and explain your reasoning.

1. $NH\_{2}^{-}+H\_{2}O \leftrightarrow NH\_{3}+OH^{-}$ equilibrium would lie to the right because OH- is a weaker base than NH2-.
2. $NH\_{3}+CH\_{3}COO^{-}\leftrightarrow NH\_{2}^{-}+CH\_{3}COOH$ equilibrium would lie to the left because CH3COO- is a weaker base than NH2-.
3. $H\_{2}O+CH\_{3}COOH \leftrightarrow H\_{3}O^{+}+CH\_{3}COO^{-}$ equilibrium would lie to the left because H2O is a weaker base than CH3COO-
4. $H\_{2}O+CH\_{3}OH \leftrightarrow H\_{3}O^{+}+CH\_{3}O^{-}$ equilibrium would lie to the left because H2O is a weaker base than CH3O-
5. $HCl+OH^{-}\leftrightarrow Cl^{-}+H\_{2}O$ equilibrium would lie to the right because Cl- is a weaker base than OH-
6. $H\_{2}SO\_{4}+CO\_{3}^{-2}\leftrightarrow HCO\_{3}^{-}+HSO\_{4}^{-}$ equilibrium would lie to the right because HSO4- is a weaker base than CO32-.
7. $HCl+H\_{2}O \leftrightarrow H\_{3}O^{+}+Cl^{-}$ equilibrium would lie to the right because Cl- is a weaker base than H2O
8. $HF+H\_{2}O \leftrightarrow H\_{3}O^{+}+F^{-}$ equilibrium would lie to the left because H2O is a weaker base than F-
9. $F^{-}+CH\_{3}COOH \leftrightarrow HF+CH\_{3}COO^{-}$ equilibrium would lie to the left because F- is a weaker base than CH3COO-.
10. $NH\_{2}^{-}+CH\_{3}OH\leftrightarrow NH\_{3}+CH\_{3}O^{-}$ equilibrium would lie to the right because CH3O- is a weaker base than NH2-

Questions 31-40: Determine which molecule is more polar and explain your reasoning using dipole moment arrows

1. (CH3)3PO vs CCl4 

Thus (CH3)3PO is more polar than CCl4

1. SOCl2 vs CS2



Thus SOCl2 is more polar than CS2

1. NH3 vs NH4+ 

Thus NH3 is more polar

1. BF3 vs PF4Cl



Thus PF4Cl is more polar

1. SO2 vs NO



Thus SO2 is more polar

1. CH3COOH vs CH3CH3



Thus CH3COOH is more polar

1. CH3MgBr vs CH3OCH3



Thus CH3MgBr is more polar

1. CH2F2 vs CH2Cl2



Thus CH2F2 is more polar than CH2Cl2

1. CH2O vs CO2



Thus CH2O is more polar

1. CH3MgBr vs CH3Li



Thus CH3Li is more polar

Questions 41-45: Rank the bonds in each of the following molecules from shortest to longest. Explain your reasoning. How does the length of these bonds correlate to their bond strength in kJ/mol?

For all of these, the shorter bonds will have a higher bond strength and thus have a larger bond dissociation energy in kJ/mol. Likewise, the longer bonds will have a lower bond strength and therefore have a smaller bond dissociation energy in kJ/mol.

1. 



The C-Br bond is the longest because Br is in the fourth row of the periodic table and therefore has a higher valence shell (its atomic radius is the largest) and the bond is a single bond. The C,C triple bond is the next longest because C has a larger atomic radius than H. The C-H single bond is the next shortest because the carbon to which the hydrogen is attached is sp3 hybridized. The finally, the C-H bond is the shortest because it is connected to a carbon that is sp hybridized and the more s character, the shorter the bond.

1. 



The C-Br bond is the longest for the same reason described above. The next shortest bond is the sp3-sp2 C-C bond because these are the next largest elements in the compound and it is a single bond. The next shortest bond is the sp3-sp3 C-O bond because this bond is between sp3 hybridized atoms and is a single bond. The next shortest bond is the sp2-sp3 C-O bond because it has more s character than the previous C-O bond. After that, the next shortest bond is the C=C double bond, this is shorter than the previous ones because it is a double bond compared to the previous single bonds and C and O have similar atomic radii. Next, we have the sp3 C-H bond as the next shortest, this bond is shorter than all the bonds before this because of how small hydrogen’s atomic radius is. Next, we have the sp2 C-H bond, this is shorter because it has more s-character. And then finally, the absolute shortest bond is the O-H bond because oxygen has a smaller atomic radius than carbon and thus irrespective of hybridization it will form shorter bonds.

1. 



1. 



1. 



Questions 46-50: Determine of the sets of cyclohexane molecules are identical, diasteromers, enantiomers, or constitutional isomers. Here, conformational isomers falls under the “identical” category. Explain your reasoning by assigning R and S.

1. 

They are identical, none of the carbons in the molecule are chiral and all carbons have the same groups thus they are identical molecules.

1. 

These molecules are diastereomers because they have the same groups, but one of the carbons has the opposite groups on the axial and equatorial bonds. The left cyclohexane has the configuration S, S while the right cyclohexane has the configuration R, S.

1. 

These molecules are enantiomers. You can see that they are clearly mirror images of each other, which is the textbook definition of enantiomers. But if you didn’t see that then you can always assign R/S as normal. 

1. 

Both cyclohexane molecules have the same groups and they are oriented in the same direction, therefore these molecules should be identical. To confirm this suspicion we can determine R/S for both chiral centers in each cyclohexane molecule and if they are the same then the molecules are the same.



1. 

Both cyclohexane molecules have the same groups on the same carbons, but they are oriented in opposite directions. Let’s see if this makes them enantiomers (it should). 

Questions 51-55: Determine if the given molecule is optically active and explain your reasoning.

1. This molecule is optically active because it has chiral carbons and has no plane(s) of symmetry.
2. This molecule is NOT optically active because while it has chiral carbons, there is an internal plane of symmetry cutting right down the center of the molecule.
3. This molecule is optically active because it has chiral carbons and there are no planes of symmetry.
4.  This molecule is not optically active and is a meso compound, it has chiral carbons but there is a plane of symmetry.
5.  This molecule is optically active because it has chiral carbons and there is no plane of symmetry.