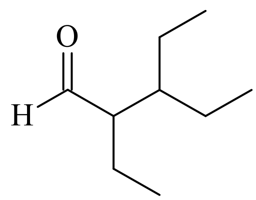
Chemistry 10123, **Exam 5** Name: ______________________________
May 1, 2019 (Please Print)

1. (12 points) Write the **complete, systematic name** of each of the following compounds. Also, on each of the structures, ***circle any carbon atoms that are asymmetric (chiral) centers***.



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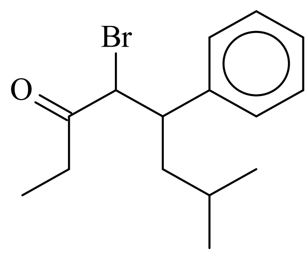

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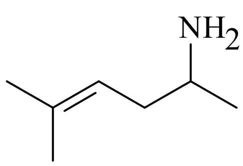

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2. Consider the following metal complexes, **A** - **D**.

   A: $[Fe(en)_3]^{2+}$ **B**: $[Ru(CN)_6]^{3-}$ **C**: $[FeCl_6]^{4-}$ **D**: $Ru(H_2O)_6{}^{3+}$

   (a) (3 points) In complex **B**, the oxidation state of Ru is __________ and the number of electrons in the 4d subshell of Ru is __________.

   (b) (2 points) Complex __________ should absorb light of longest wavelength.

   (c) (3 points) Three of these complexes are "low-spin" and one is "high-spin." The high-spin complex is __________ and it has __________ unpaired electrons.

   (d) (4 points) Sketch a properly labeled ***d-orbital splitting diagram*** for the above ***high-spin complex*** that accounts for the number of unpaired electrons. Indicate on your diagram what feature is related to the wavelength of absorbed light.

3. (2 points) Which of the following complexes are capable of exhibiting ***linkage isomers***? **Circle your answers(s)**. (en = ethylenediamine)

$[Cr(en)_2Br_2]^+$ $[Cr(NH_3)_5NO_2]^{2+}$ $[Cr(en)(NH_3)_3OCN]^{2+}$ $[Cr(en)_2(C_2O_4)]^+$

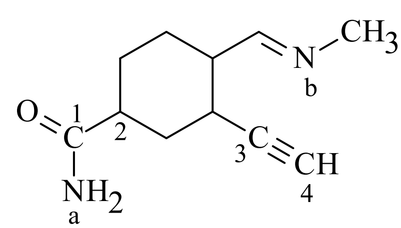
4. For each of the following metal complexes, draw clear, ***3-dimensional structures*** of all possible ***isomers*** (geometric and/or optical). Also, for each one, write the term that best describes the structure (i.e., pyramidal, linear, etc.). (en = ethylenediamine) ***Points will be deducted if the same structure is drawn more than once!***

(a) (2 points) $Hg(NH_3)_2(CN)_2$ ____________________

(b) (3 points) $Cu(NH_3)_2(CN)_2$ ____________________

(c) (5 points) $Mn(en)_2(CN)_2$ ____________________

5. (10 points) Consider the molecule on the right from the viewpoint of bonding and structure concepts. (The small numbers and letters next to the formula are simply labels that refer to the selected carbon and nitrogen atoms in the following questions.)



(a) Insert any lone electron pairs that are not shown in the structure.

(b) What is the hybridization at each of the following atoms?

C^2 ________ O ________ C^4 ________ N^b ________

(c) What are the approximate bond angles around each of the following centers?

C^1 ___________ C^4 ___________ N^a ___________

(d) On the structure above, circle the ***shortest*** covalent bond in the molecule.

(e) Write the ***empirical formula*** of this compound (i.e., in a format like $C_3H_7NO_2$).

<u>All</u> of the remaining questions on this exam deal with isomers of C_4H_8O !

Perhaps surprisingly, there are over twenty ***structural isomers*** of the simple organic formula **C_4H_8O**. (This does not include geometric, i.e., *cis-trans* isomers). Many of these isomers contain <u>multiple bonds and/or rings</u>. Based on information provided in the following questions, identify ***fourteen specific isomers of*** **C_4H_8O**, i.e., the compounds labeled **1 - 14**.

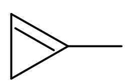
<u>Note</u>: Complete, ***specific structural formulas*** are required for compounds **1 - 14** and for all other ***organic compounds*** that are ***underlined***. Understand that *compounds* **1 - 14** *are all isomers* of **C_4H_8O** but the underlined compounds are not.

6. (3 points) Compound **1** is the only ***ketone*** of formula C_4H_8O. Write both the structural formula and the ***systematic name*** of **1**.

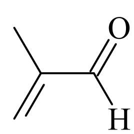
7. (5 points) Compound **2** can be converted in two steps to butanamide.

2 $\xrightarrow{[O]}$ <u>an acid</u> $\xrightarrow{NH_3}$ <u>butanamide</u>

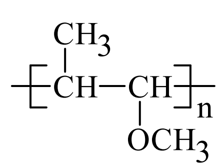
8. (3 points) Compound **3** can be made via addition of H_2O to a certain alkene as follows.

 $\xrightarrow{H_2O}$ **3**

9. (3 points) Compound **4** oxidizes to form the organic product shown below.

4 $\xrightarrow{[O]}$ 

10. (4 points) Compound **5** polymerizes as follows. What ***type of polymerization*** is this?

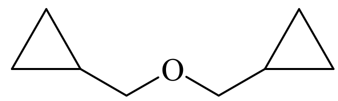
5 $\xrightarrow{h\nu}$ 

11. (4 points) Compound **6** undergoes an elimination reaction to form cyclobutene.

$$\mathbf{6} \xrightarrow[-\ H_2O]{H^+} \underline{\text{cyclobutene}}$$

12. (3 points) Compound **7** can be converted to an unusual looking ether as shown.

$$\mathbf{7} \xrightarrow[\Delta]{H^+}$$



13. (6 points) Compound **8** undergoes addition of HBr to yield a product of empirical formula C_4H_9BrO that subsequently reacts with more HBr to produce 2,3-dibromobutane.

$$\mathbf{8} \xrightarrow{HBr} \underline{C_4H_9BrO} \xrightarrow{HBr} \underline{\text{2,3-dibromobutane}}$$

14. (5 points) An important method (known as the Wittig reaction) for the formation of C=C double bonds involves the reaction of carbonyl compounds with a phosphorus reagent, e.g., $Ph_3P{=}CH_2$ (where Ph = phenyl), called an ylide. The formation of the very stable phosphorus oxide, $Ph_3P{=}O$, is the driving force for the reaction. A simple example, starting with acetone, is shown below.

$$(H_3C)_2C{=}O \xrightarrow[-\ Ph_3P{=}O]{Ph_3P{=}CH_2} (H_3C)_2C{=}CH_2$$

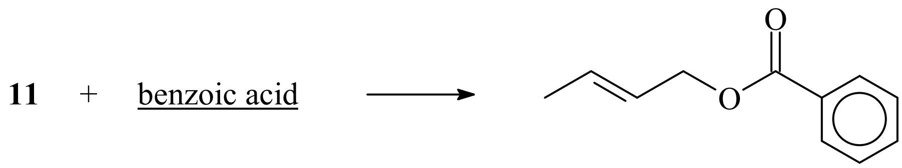
Using the Wittig process, compound **9** can be easily converted to 2,4-dimethyl-2-pentene.

$$\mathbf{9} \xrightarrow[-\ Ph_3P{=}O]{Ph_3P{=}C(CH_3)_2} \underline{\text{2,4-dimethyl-2-pentene}}$$

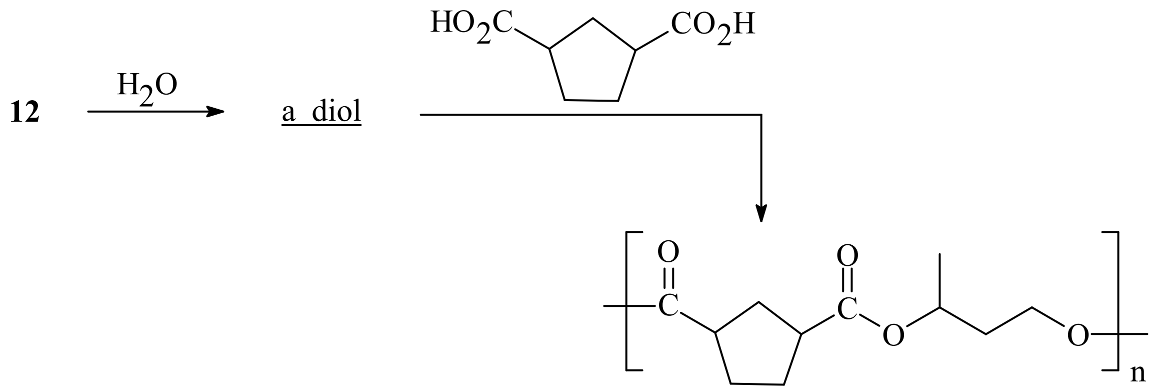
15. (4 points) Compound **10** polymerizes as shown below. What ***type of polymerization*** is this?

$$\mathbf{10} \longrightarrow \left[CH_2-\underset{}{\overset{CH_3}{\overset{|}{C}}}H-CH_2-O \right]_n$$

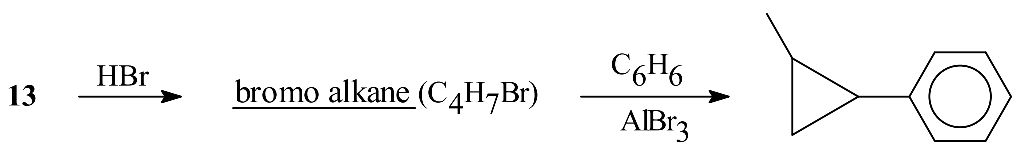
16. (4 points) Compound **11** reacts with benzoic acid as shown below.



17. (5 points) Compound **12** adds water to form a ***diol*** that, in turn, reacts with a diacid to yield a polymer as shown below. What ***type of polymerization*** is this?



18. (5 points) Compound **13** reacts with HBr to form a bromoalkane (C_4H_7Br) which then reacts with benzene (and a catalytic amount of $AlBr_3$) as shown below.



19. **EXTRA CREDIT.** (4 points) Compound **14** has ***no double bonds*** but still exhibits a type of geometric isomerization (i.e., *cis* and *trans*) due to its unique structure. Identify compound **14** and ***clearly draw*** its *cis* and *trans* isomers.