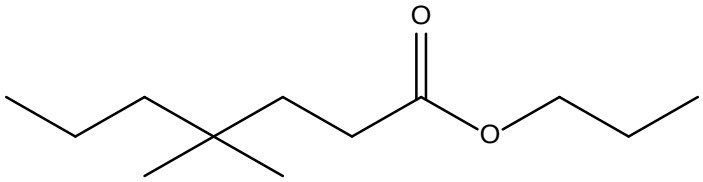
Chemistry 101 - Exam I ***Name _____***

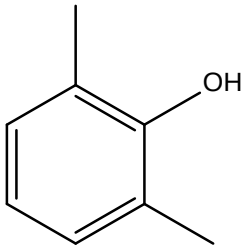
27 September 2017

Show all work for credit. State any assumptions made to solve a problem. Give all numerical answers with the correct number of significant figures. All answers in scientific notation must be in correct scientific notation (i.e., 6.022×10^{23} not 6.022E23 or 6.022e23). All instances of incorrect scientific notation will result in the loss of 3 points each. All numbers that require units should have the units written. All instances of numbers without units will result in the loss of 3 points each.

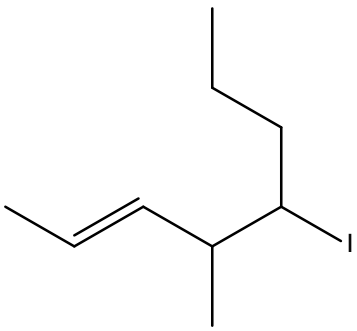
1. (24 pts) Name the following organic compounds:

a. 

propyl 4,4-dimethylheptanoate

b. 

2,5-dimethylphenol

c. 

5-iodo-4-methyloct-2-ene

2. (29 points) By analysis, a compound was found to contain 86.37 % mercury and 4.45 % phosphorus by mass; the remainder was oxygen. What is the oxidation state of mercury in this compound? What is the name of the compound?

$$86.37\ \text{g Hg} \times \frac{1\ \text{mol Hg}}{200.592\ \text{g Hg}} = 0.4305754\ \text{mol Hg} / 0.1436699\ \text{mol} = 2.996975 \approx 3\ \text{Hg}$$

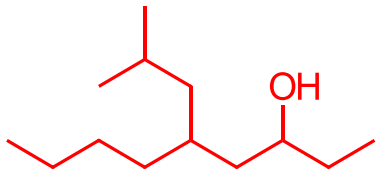
$$4.45\ \text{g P} \times \frac{1\ \text{mol P}}{30.973761998\ \text{g P}} = 0.1436699\ \text{mol P} / 0.1436699\ \text{mol} = 1.0000\ \text{P}$$

$$\left(100.00 - 86.37 - 4.45\right)\ \text{g O} \times \frac{1\ \text{mol O}}{15.9994\ \text{g O}} = 0.5737715\ \text{mol O} / 0.1436699\ \text{mol} = 3.993676 \approx 4\ \text{O}$$

The empirical formula is Hg_3PO_4. The oxidation state of mercury is +1 and the name of the compound is mercury(I) phosphate ($(Hg_2)_3(PO_4)_2$).

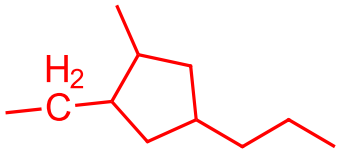
3. (21 points) Write formulas for the following compounds:

   a. 5-(2-methylpropyl)nonan-3-ol



   b. Para-xylene

   c. 1-ethyl-2-methyl-4-propylcyclopentane



4. (19 pts) The hormone estrogen contains carbon, hydrogen, and oxygen. When burned in an excess of oxygen, a 1.6534 g sample yields 4.7563 g CO_2 and 1.2980 g H_2O. The compound has a molecular mass of 272.382 u. What is the molecular formula of testosterone?

$$4.7563\text{ g CO}_2 \times \frac{1\text{ mol CO}_2}{44.0095\text{ g CO}_2} \times \frac{1\text{ mol C}}{1\text{ mol CO}_2} = 0.1080743\text{ mol C} \times \frac{12.0107\text{ g C}}{1\text{ mol C}} = 1.298049\text{ g C}$$

$$1.2980\text{ g H}_2\text{O} \times \frac{1\text{ mol H}_2\text{O}}{18.0153\text{ g H}_2\text{O}} \times \frac{2\text{ mol H}}{1\text{ mol H}_2\text{O}} = 0.1440997\text{ mol H} \times \frac{1.00794\text{ g H}}{1\text{ mol H}} = 0.1452438\text{ g H}$$

$$\text{g O} = 1.6354\text{ g} - 1.298049\text{ g} - 0.1452438\text{ g} = 0.1921069\text{ g O} \times \frac{1\text{ mol O}}{15.9994\text{ g O}} = 0.01200713\text{ mol O}$$

$$\frac{0.1080743\text{ mol C}}{0.01200713\text{ mol}} = 9.000845\text{ C} \qquad \frac{0.1440997\text{ mol H}}{0.01200713\text{ mol}} = 12.00117\text{ H} \qquad \frac{0.01200713\text{ mol O}}{0.01200713\text{ mol}} = 1.00000$$

The empirical formula is $C_9H_{12}O$ with an empirical mass of 132.1909 u.

$$n = \frac{\text{molecular mass}}{\text{empirical mass}} = \frac{272.382\text{ u}}{132.1909\text{ u}} = 2.000000$$

The molecular formula is $C_{18}H_{24}O_2$.

5. (26 pts) 126.343 g of pentandial, a dialdehyde, was burned in 250.637 g of oxygen gas. The products are carbon dioxide gas and liquid water. How many grams of liquid water are produced if the percent yield is 86.443%?

$$HOCCH_2CH_2CH_2CHO + 6\ O_2 \rightarrow 5\ CO_2 + 4\ H_2O$$

$$126.343\ g\ C_5H_8O_2 \times \frac{1\ mol\ C_5H_8O_2}{100.1158\ g\ C_5H_8O_2} \times \frac{4\ mol\ H_2O}{1\ mol\ C_5H_8O_2} \times \frac{18.0153\ g\ H_2O}{1\ mol\ H_2O} \times \frac{86.443\ g\ actual}{100.000\ g\ theoretical} = 78.610\ g\ H_2O$$

$$250.637\ g\ O_2 \times \frac{1\ mol\ O_2}{31.9988\ g\ O_2} \times \frac{4\ mol\ H_2O}{6\ mol\ O_2} \times \frac{18.0153\ g\ H_2O}{1\ mol\ H_2O} \times \frac{86.443\ g\ actual}{100.000\ g\ theoretical} = 81.319\ g\ H_2O$$

78.610 g of water are produced.

6. (31 points) 0.1768 g of an impure sample containing propanoic acid is titrated with a 0.02634 M $KMnO_4$ solution. Two of the products of the reaction are the manganese(II) ion and carbon dioxide. The titration required 33.11 mL of the $KMnO_4$ solution to reach a faint pink endpoint. What is the percent by mass of propanoic acid in the sample?

$$\underset{-2/3\ +1\ -2}{C_3H_6O_2} + \underset{+1\ \ +7\ \ -2}{KMnO_4} \rightarrow \underset{+2}{Mn^{2+}} + \underset{+4\ -2}{CO_2}$$

$$5(4\ H_2O + C_3H_6O_2 \rightarrow 3\ CO_2 + 14\ H^+ + 14\ e^-)$$
$$14(5\ e^- + 8H^+ + KMnO_4 \rightarrow Mn^{2+} + K^+ + 4\ H_2O)$$

$$\cancel{60\ e^-} + \cancel{20\ H_2O} + \cancel{100}\ H^+ + 5\ C_3H_6O_2 + 14\ KMnO_4 \rightarrow 15\ CO_2 + 14\ Mn^{2+} + \cancel{60\ H^+} + \cancel{56}\ H_2O + \cancel{60\ e^-}$$
$$40\ H^+ + 5\ C_3H_6O_2 + 14\ KMnO_4 \rightarrow 14\ Mn^{2+} + 36\ H_2O + 15\ CO_2$$

$$\frac{33.11\ mL\ KMnO_4\ sol'n}{0.1768\ g\ sample} \times \frac{0.02634\ mol\ KMnO_4}{1000\ mL\ KMnO_4\ sol'n} \times \frac{5\ mol\ C_3H_6O_2}{14\ mol\ KMnO_4} \times \frac{74.0785\ g\ C_3H_6O_2}{1\ mol\ C_3H_6O_2} \times 100$$
$$= 13.05\%\ by\ mass\ C_3H_6O_2$$