

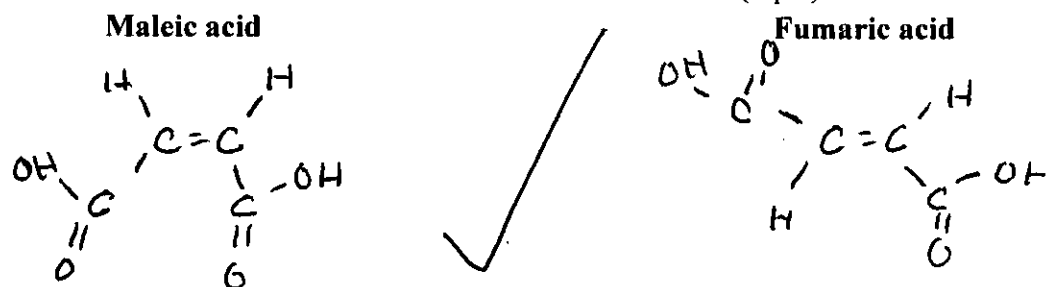
CHEM 162 – Lab 3 Report Worksheet

Part I. Properties, Intra- and Inter- Molecular Forces and Structure of Maleic and Fumaric acids

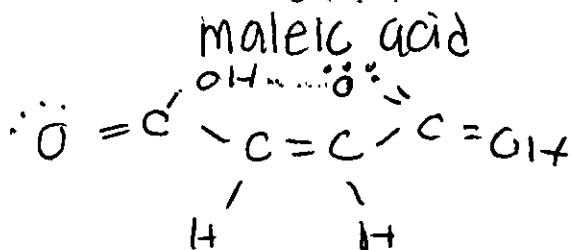
This report is due before you leave lab. You can talk with any of your fellow students about the work, but the TAs are not allowed to answer any questions about this part during the lab.

Maleic acid and fumaric acid are stereoisomers of each other with the molecular formula $C_4H_4O_4$ or $COOH-CH=CH-COOH$. Maleic acid is the *cis* form and the *trans* form is fumaric acid. (See the Zumdahl text for explanations of *cis* and *trans*.) Build a model of each molecule and, based on your observations, answer the following questions:

1. Draw the 3-D Lewis structures of each molecule. (2 pts)



2. Which molecule is able to form intramolecular hydrogen bonding? Draw the Lewis structure of this molecule and use dotted lines to show the intramolecular hydrogen bonding. (3 pts)



3. If a substance forms *intramolecular* hydrogen bonding, is it more or less likely to form *intermolecular* hydrogen bonding? (Circle correct response) (1 pt)

A. More
B. Less

4. Which of the two molecules do you expect to have a higher melting point? Why? (4 pts)

Circle response: maleic acid

fumaric acid

Explain your answer:

It is a more stable compound because it has intermolecular bonding which is stronger in this case since h-bonding

(-1)

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5. Report the melting points of substances A and B, based on your measurements using the melting point apparatus. (2 pts)

Melting point of A 298-300 °C
270-310

Melting Point of B 139-141 °C
130-170

6. Report the pH of 0.010 M solutions of the two acids. (2 pts)

pH of A 2.62

pH of B 2.29

7. Based on the measured pH for each of the 0.010 M solutions, calculate the K_{a1} values (assume K_{a2} does not contribute significantly to the pH) (4 pts)

Show a sample calculation:

$$K_a = \frac{[H^+]^2}{A - [H^+]}$$

$$10^{-pH} = [H^+]$$

$$= \frac{[0.002398]^2}{0.01}$$

$$5.75 \times 10^{-4}$$

K_{a1} of substance A 5.75 × 10⁻⁴

$$K_a = \frac{[0.00512]^2}{0.01}$$

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{x^2}{[A]}$$

$$2.63 \times 10^{-3}$$

K_{a1} of substance B 2.63 × 10⁻³

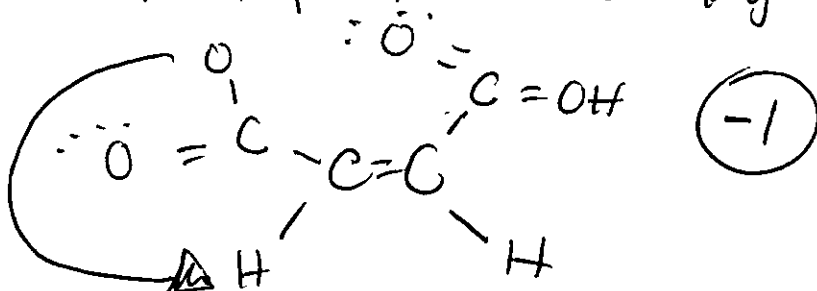
8. Consider the compound with intramolecular hydrogen bonding. Deprotonate one of the -COOH groups (K_{a1}) and, remembering that the deprotonated form is actually -COO⁻ (minus charge!), reconsider intramolecular hydrogen bonding and decide whether or not intramolecular hydrogen bonding becomes more favorable or less favorable upon deprotonation. (4 pts)

Circle response: Less favorable

More favorable

Explain your answer (a detailed drawing is acceptable):

We want O to be ~~neutral~~ neutral and it will rotate on its ~~single~~ single bond to meet up w/ another Hydrogen intramolecularly



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9. Based on the data you have collected and after considering of the intramolecular hydrogen bonding, identify the unknown substances as maleic or fumaric acid. (2 pts)

ID of Substance A Fumaric acidID of substance B maleic acid

10. Fumaric acid has a K_{a2} of 3.63×10^{-5} and maleic acid has a K_{a2} value of 8.51×10^{-7} . Based on your observations of the two doubly-deprotonated forms of the two acids, explain the large difference in the K_{a2} values. HINT: Consider charges on the two -COO^- units. (3 pts)

the large difference in the K_{a2} values is because the double deprotonated form lacks hydrogen bonding causing the COO^- units to repel one another due to like charges, therefore weakening K_a value.

11. Do you expect the K_{a1} value for succinic acid $\text{HOOC-CH}_2\text{-CH}_2\text{-COOH}$ to be closer to that of fumaric or maleic acid? Explain your answer. (3 pts)

Circle response: fumaric acid maleic acid

Explain your answer:

It has a ~~more~~ more similar Lewis dot structure and H-bonding

