**Background:** Turmeric powder is an inexpensive yellow-orange spice that is used to give some brands of mustard a bright yellow color. This color derives principally from curcumin (1, 2).

![Diagram of curcumin structures](image)


**Review Questions:**

1. Apply what you know about conjugated $\pi$-bonding systems to explain why the maximum absorbance wavelength for the keto-enol tautomer 1 should be longer than that for diketone 2.

2. There has been some debate in the scientific literature about whether the keto-enol tautomer 1 or diketone 2 predominates at neutral pH~7. If the calculations for the maximum absorbance wavelength are correct, which of these compounds do you see on the initial yellow paper? Why might that compound be more stable?

**Recall:** When light is absorbed, your eye detects the complementary color.

<table>
<thead>
<tr>
<th>Wavelength of light</th>
<th>Complementary Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet: 400 - 420 nm</td>
<td>Yellow</td>
</tr>
<tr>
<td>Indigo: 420 - 440 nm</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue: 440 - 490 nm</td>
<td>Orange</td>
</tr>
<tr>
<td>Green: 490 - 570 nm</td>
<td>Red</td>
</tr>
<tr>
<td>Yellow: 570 - 585 nm</td>
<td>Indigo &amp; Violet</td>
</tr>
<tr>
<td>Orange: 585 - 620 nm</td>
<td>Blue</td>
</tr>
<tr>
<td>Red: 620 - 780 nm</td>
<td>Green</td>
</tr>
</tbody>
</table>

3. In principal, water can affect the interconversion of keto-enol tautomer 1 and diketone 2. Draw arrow-pushing mechanisms using water to interconvert 1 and 2.

Watch the video of the procedure ([https://www.youtube.com/watch?v=0afSRIczBco](https://www.youtube.com/watch?v=0afSRIczBco)) and carefully observe what happens. Then, respond to the below questions, which require you to draw on your observations and your knowledge of organic synthesis.

In the video, a series of solutions were prepared by adding to water one of the following:

(a) A teaspoon of baking soda (sodium bicarbonate, NaHCO$_3$). Assume a solution pH~9.
(b) Vinegar, which contains acetic acid (CH$_3$CO$_2$H). Assume this solution has a pH~2.
(c) Concentrated household bleach, which contains NaOCl. Assume a solution pH~13.
(d) Water. Assume this solution has a pH~7.
4. If the calculations and experimental values for the maximum absorbance wavelength are correct, which compounds could be responsible for the red color in the paper? See below for possible structures.

5. Draw an arrow-pushing mechanism to explain why the baking soda solution transformed the yellow paper to red paper. What is the role of baking soda in this reaction?

6. Draw an arrow-pushing mechanism to explain why the vinegar solution transforms the red paper to yellow paper. What is the role of vinegar in this reaction?

7. Why doesn’t the vinegar solution cause the yellow paper to change colors?

8. After exposure to the bleach solution, the initially yellow paper becomes red and then eventually becomes colorless. Speculate about why the paper changes from red to colorless. Chemically, what might this process entail?

Hints:
8a. All of the depicted structures are in dynamic equilibrium, so if one of these structures is present, there is likely to be some small amount of all of the others (which would mean that if any of these compounds was present, the sheet of paper might remain colored).
8b. Pretend that reactivity starts with compound 2 for this question.

9. Write 1-2 sentences to explain what you have learned from this worksheet.

10. Was this exercise useful? Why or why not? Provide 1-2 suggestions to improve this worksheet.

The initial draft of this worksheet was prepared by Tanya Thomas, Miranda Allen, Gilbert Brooks, III, Bashir Adeed (2015) to accompany their procedural video. It has been adjusted by Prof. Jennifer Roizen and Mr. Mina Shehata (2016).