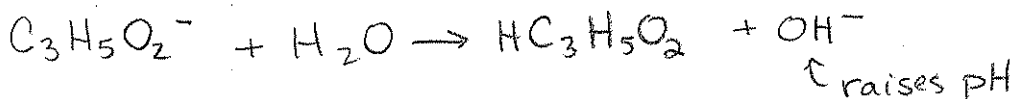


1. These questions concern the weak base sodium propionate,  $\text{NaC}_3\text{H}_5\text{O}_2$ .  $\rightarrow$   $\text{Na}^+$ ,  $\text{C}_3\text{H}_5\text{O}_2^-$  basic  
*no effect on pH*
- a. An aqueous solution of sodium propionate has  $\text{pH} > 7$ . Write a balanced net ionic equation to explain this observation.



- b. You add the following indicators to separate samples of the sodium propionate solution and note the resulting colors (see last column):

Indicator	pH Interval of Color Change	Color Change	Color in $\text{NaC}_3\text{H}_5\text{O}_2(\text{aq})$
Bromcresol green	3.8 - 5.4	Yellow to blue	blue $\Rightarrow \geq 5.4$
Bromthymol blue	6.0 - 7.6	Yellow to blue	blue $\Rightarrow \geq 7.6$ *
Phenol red	6.8 - 8.2	Yellow to red	orange $\Rightarrow \sim 7-8$
Thymol blue	8.0 - 9.6	Yellow to blue	yellow $\Rightarrow \leq 8.0$ *
Thymolphthalein	9.3 - 10.5	Yellow to blue	yellow $\Rightarrow \leq 9.3$

Estimate the pH of the sodium propionate solution as precisely as you can: 7.6 - 8.0

- c. If you wanted to convert 1L of 0.10M sodium propionate solution to a buffer,

$\sim 0.05$  mol HCl could be added to make  $0.05$  mol  $\text{HC}_3\text{H}_5\text{O}_2$  (+  $0.05$  mol  $\text{C}_3\text{H}_5\text{O}_2^-$  left over)

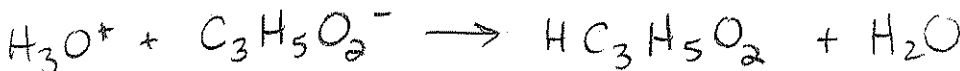
What would you add (provide a chemical formula)?  $\text{HC}_3\text{H}_5\text{O}_2$

About how much of it (in moles) would you need to add?  $\sim 0.1$  mole

No complex calculations are required.  
moles base = moles acid =  $1\text{L} * 0.10\text{M} \rightarrow 0.1\text{mol}$

- d. Write a balanced equation (any type) that explains how your new buffer resists changes in pH if HCl is added.

$\rightarrow$  source of  $\text{H}_3\text{O}^+ \Rightarrow$  eqn must show how this is consumed



2. Here are some data you can use to calculate the molar absorptivity of an indicator. Calculate  $\epsilon_{\text{HIn}}$  and show how you find its units. (Recall:  $A_\lambda = \epsilon_\lambda bC$  and  $A_{\lambda, \text{total}} = A_{\lambda, \text{HIn}} + A_{\lambda, \text{In}^-}$ )

To find  $\epsilon_{\text{HIn}}$ , measure  $A$  when only  $\text{HIn}$  absorbs (as we did in our expt).

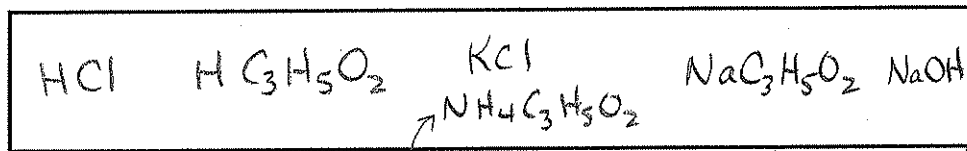
$b$	1.00 cm
$A_{\lambda, \text{HIn}}$	0.002
$A_{\lambda, \text{In}^-}$	0.742
$C_{\text{Indicator}}$	$1.59 \times 10^{-5} \text{M}$

$$\begin{aligned} \epsilon_{\text{HIn}} &= A_{\text{HIn}} / b C_{\text{HIn}} \\ &= (0.002) / (1.00\text{cm})(1.59 \times 10^{-5} \text{M}) \\ &= \boxed{1 \times 10^2 \text{ cm}^{-1} \text{ M}^{-1}} \end{aligned}$$

3. Rank the following solutions in order of increasing pH:

<sup>WB</sup> NaC<sub>3</sub>H<sub>5</sub>O<sub>2</sub>, <sup>SA</sup> HCl, <sup>WA</sup> HC<sub>3</sub>H<sub>5</sub>O<sub>2</sub>, <sup>neutral</sup> KCl, <sup>SB</sup> NaOH, <sup>WA</sup> NH<sub>4</sub>C<sub>3</sub>H<sub>5</sub>O<sub>2</sub> <sup>WB</sup>

Low pH



High pH

neutral, but need more info about relative strengths of NH<sub>4</sub><sup>+</sup> vs C<sub>3</sub>H<sub>5</sub>O<sub>2</sub> to place more precisely

4. To measure the pK<sub>a</sub> of an indicator ("HIn"), you make three solutions from the stock indicator (3.75 × 10<sup>-4</sup> M) as described below. From earlier pH paper tests, you are sure that the indicator undergoes a color transition between pH 5.5-7.5.

SOLUTION A: 3.00 mL stock indicator + 5 mL 1M HCl + water to 25.0 mL  
 SOLUTION B: 3.00 mL stock indicator + 5 mL 1M NaOH + water to 25.0 mL  
 SOLUTION C: 3.00 mL stock indicator + phosphate buffer (pH 6.5) to 25.0 mL

a. Which solution has the highest pH? *strong base present* A  B  no difference

b. Which probably has the highest concentration of HIn? *more H<sub>3</sub>O<sup>+</sup> is present to protonate In<sup>-</sup>* A  B  no difference

c. What is the total concentration of indicator in SOLUTION A? *C = (3.00 mL \* 3.75 × 10<sup>-4</sup> M) / 25.0 mL* 4.50 × 10<sup>-5</sup> M

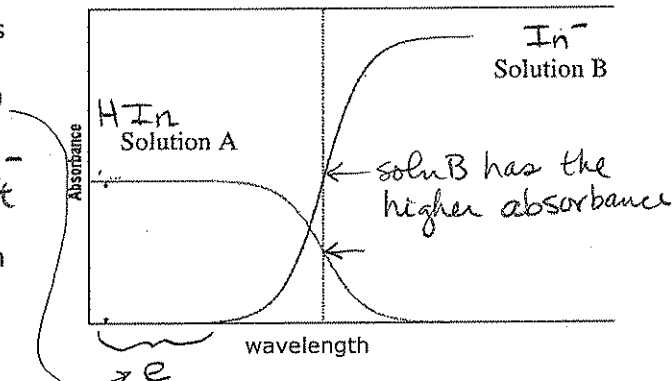
d. If the indicator actually has a pK<sub>a</sub> = 6, predict the ratio of [In<sup>-</sup>]/[HIn] in SOLUTION C. *at pK<sub>a</sub>, [In<sup>-</sup>] = [HIn]; at higher pH ⇒ less H<sup>+</sup> ⇒ [In<sup>-</sup>] ↑ and [HIn] ↓* ratio is <1 =1  >1

e. At right are the spectra for two of the solutions you made. You decide to measure the concentration of HIn in SOLUTION C. Show on the graph a good wavelength to use for this measurement.

*any λ where HIn absorbs but In<sup>-</sup> does not*

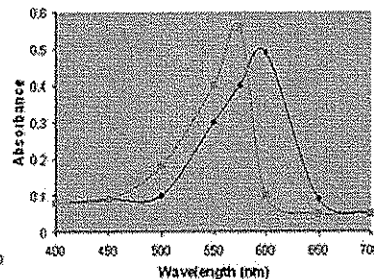
f. Which solution, A or B, has the greater molar absorptivity (ε) at the wavelength marked with vertical line? B

$\epsilon = A/bC$  *← same for both*  
*← same*

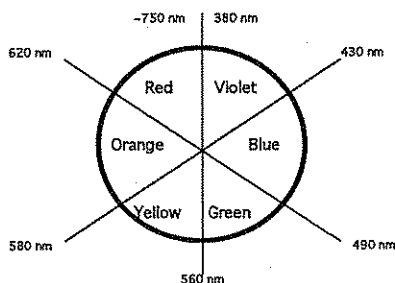


**A bonus question:**

A potential acid-base indicator has two colored forms, HIn, and In<sup>-</sup>. The spectra are shown at right (for purposes of answering this question, it doesn't really matter which spectrum corresponds to which form). Will this make a useful indicator? Explain in 15 words or less.



No. Spectra show that HIn & In<sup>-</sup> are same color ⇒ won't see a dramatic color change going from HIn → In<sup>-</sup>



color seen is color transmitted (where absorbance is low)