Acid Equilibrium Constant for Methyl Red

Purpose: Did you use your original solutions?

- Use Beer's Law to determine absorbance and solve for concentration of [HIn]
- Use Beer's Law to determine absorbance and solve for concentration of [In-]
- Determine pKa using Henderson – Hasselbach equation pH = pKa + log([A^-]/[HA])
- Check accuracy and precision of pKa using percent error and CV
- HIn ⇆ H^++In^-

Reference:

(1) Kateley, L. J., *Introduction to Chemistry in the Laboratory, 20th Ed.*, Lake Forest College, **2021,** Experiment 7_Acid_Equilibrium_for_Methyl_Red Appendix C_Spectorscopy.

Prepare Solutions of HIn

- Pink transparent solution that darkened with concentration
- Relativly even amounts in each vial
- Blank of deionized water

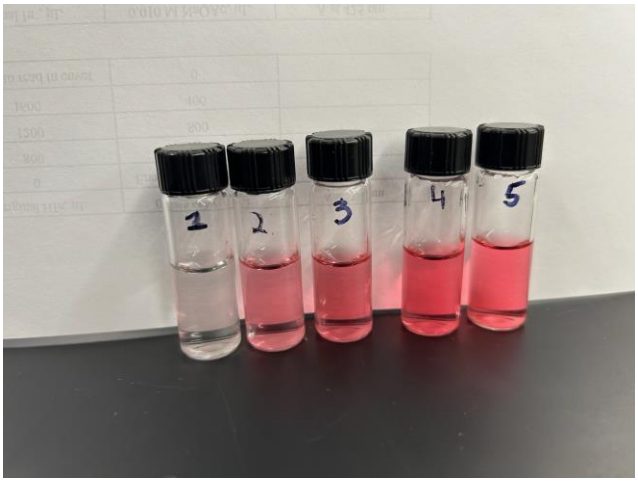
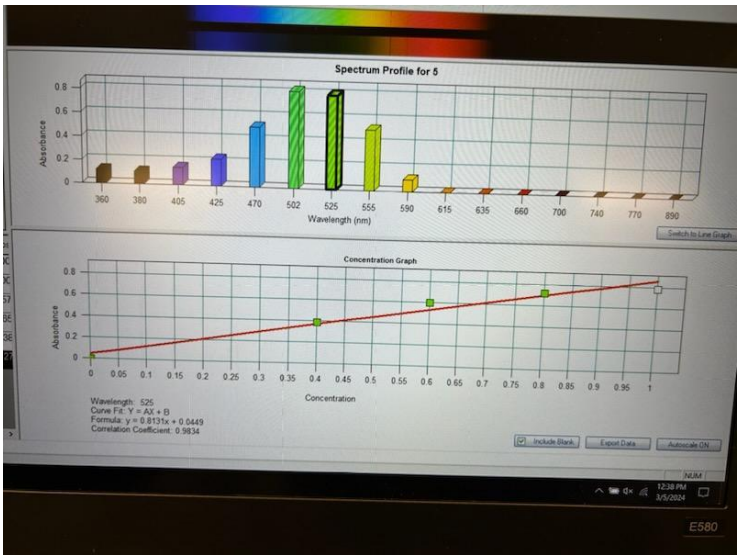


TABLE 1: HIn/ Red SOLUTIONS, pH 2

Solution	Relative conc., C	Original HIn, µL	0.010 M HCl, µL	A at 520 nm
1, blank	0	0	*Provided*	0
2	0.400	1200	1800	0.388
3	0.600	1800	1200	0.604
4	0.800	2400	600	0.722
5	1.000	Enough to read in vial	0	0.786



Calculations:

A_{525} = kC + intercept

A_{525} = 0.8131[HIn] + 0.0449

Fit = 0.9951

- The fit is good , intercept small

Prep In^- Solutions

- Saturated yellow transparent solution that darkened with concentration
- Even amounts of solution in each vial
- Same blank of deionized water from HnI solutions used

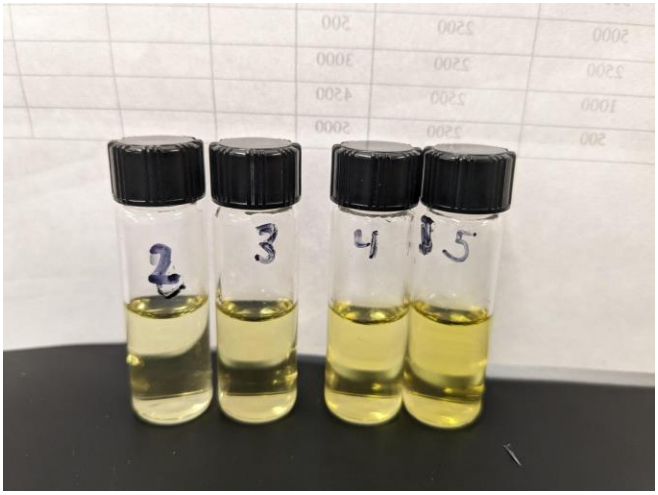


TABLE 2: In^-/ Yellow SOLUTIONS, pH 8

Solution	Relative conc., C	Original In^-, µL	0.010 M NaOAc, µL	A at 425 nm
6, blank	0	0	*Provided*	0
7	0.400	1200	1800	0.234
8	0.600	1800	1200	0.345
9	0.800	2400	600	0.528
10	1.000	Enough to read in vial	0	0.786

Calculations:

$A_{425} = k_{425}[In^-] + intercept$

$A_{425} = 0.6188[In^-] - 0.0054$

Fit = 0.9951

- The fit is good , intercept small, close to zero

Prep Buffer Solution of In^-

- 0.020M HOAc, 0.04M NaOAC, and standardized methyl red of varying concentrations
- Colors ranged from pale red (highest concentration of HOAc) to golden yellow (lowest concentration of HOAc)

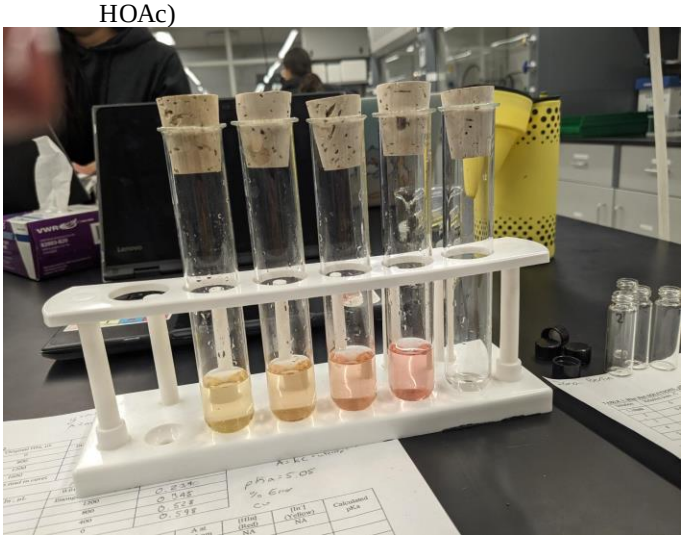


TABLE 3: BUFFERED SOLUTIONS

Soln	Std me red, µL	0.02 M HOAc, µL	0.04 M NaOAc, µL	H_2O, µL	pH	A at 520 nm	A at 425 nm	[HIn] (Red)	$[In^-]$ (Yellow)	Calculated pK_a
11, blank	0	500	500	1000	NA	0	0	NA	NA	NA
12	2000	5000	2500	500	4.83	0.199	0.158	0.190	0.264	4.78
13	2000	2500	2500	3000	5.12	0.158	0.153	0.139	0.256	4.90
14	2000	1000	2500	4500	5.55	0.139	0.139	0.116	0.282	5.17
15	2000	500	2500	5000	5.77	0.113	0.185	0.0838	0.308	5.32

Sample Calculations for Vial 12:

Calculation 1 : [HIn]

$A_{525} = 0.8131[HIn] + 0.0449$

$0.199 = 0.813[HIn] + 0.0449$

$[HIn] = 0.190M$

Calculation 2: $[In^-]$

$A_{425} = 0.6188[In^-] - 0.0054$

$0.158 = 0.619[In^-] - 0.0054$

$[In^-] = 0.263M$

Calculation 3: pKa

$pH = pKa + \log([In^-]/[HIn])$

$4.90 = pKa + \log(0.264/0.190)$

$pKa = 4.78$

Calculation 4: Overall calculations

pKa mean = (4.78 + 4.90 + 5.17 + 5.32)/4 = 5.04

Standard deviation = 0.247 0.25

CV = 0.2547/5.04 x 100 = 4.9%

Percent error = 5.04-5.05/5.05 x 100 = 0.2%

- Good accuracy and bad precision