Titration 2: Standardization of NaOH with KHP and Using Standardized NaOH to Determine Mass of Unknown Diprotic Acid

Purpose:

- **Standardize NaOH solution with KHP to get concentration to four significant figures Chem Eq?**
- **Evaluating precision of standardization of NaOH from triplicates**
- **Use titration of unknown diprotic acid with standardized NaOH to determine molecular weight of unknown diprotic acid to four significant figures. H2X + 2 NaOH...**
- **Evaluating precision and accuracy of calculated molecular weight from triplicates**

Reference:

(1) Kateley, L. J., *Introduction to Chemistry in the Laboratory, 20th Ed.*, Lake Forest College, **2021,** Experiment Titration 2 Appendix B_AccuracyErrorPercision

Standardization of NaOH

Burette prepped with ~0.1M NaOH

- Burette drained of deionized water
- 400mL beaker filled with ~250mL of ~0.1M NaOH from box on the left
- Rinsed 3 times with ~5mL of NaOH solution and finally filled

Flasks of KHP prepped

- 0.3 - 0.4 g of KHP added to each flask
- ~30mL of deionized water added to each flask
- One drop of indicator phenolphthalein added to each flask
- Indicator starts clear in acid and turns pink in presence of base

Titration of KHP to Pink End Point

- NaOH base is titrant
- KHP acid analyte
- Run off ~10mL

$NaOH(aq) + KHP(aq) \Leftrightarrow KNaP(aq) + H_2O(l)$

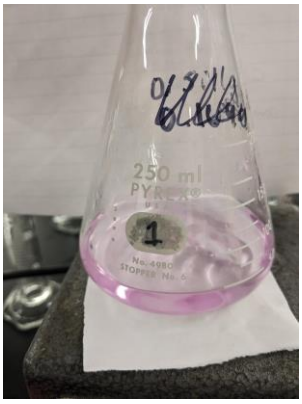
	Trial 1	Trial 2	Trial 3	Trial 4
Mass of KHP (g)	0.3060	0.3515	0.3575	0.3292
Mol of KHP/NaOH	0.001498	0.001721	0.001751	0.001612
Initial NaOH(mL)	0.35	0.27	0.48	0.25
Final NaOH(mL)	13.31	15.22	17.62	13.98
Total NaOH (mL)	12.96	14.95	17.14	13.73
Color of Final Solution	Pale Pink	Pale Pink	Medium Pale Pink	Pale Pink
M NaOH	0.1156	0.1151	0.1022	0.1174

Calculations for standardization of NaOH

Trial 1:

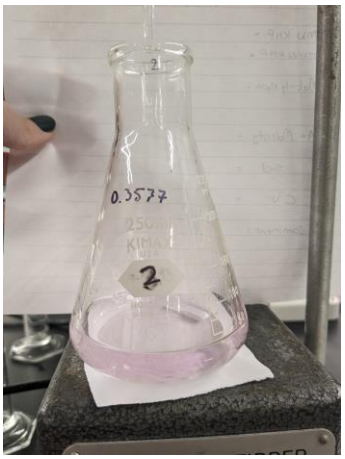
0.3060g KHP(1mol KHP/204.22g KHP) = 0.001498mol KHP = 0.001498mol NaOH

0.001498mol NaOH/12.96mL (1000mL/1L) = 0.1156M



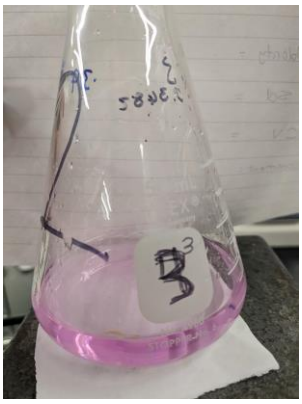
Trial 2:

0.3515g KHP(1mol KHP/204.22g KHP) = 0.001721mol KHP = 0.001721mol NaOH
0.001721mol NaOH/14.95mL (1000mL/1L) = 0.1151M



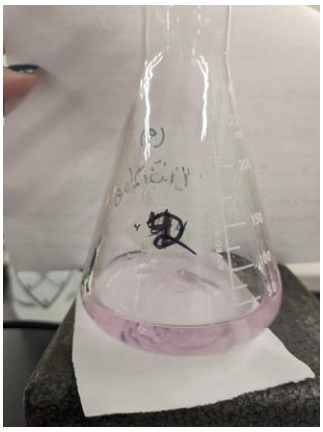
Trial 3:

0.3575g KHP(1mol KHP/204.22g KHP) = 0.001751mol KHP = 0.001751mol NaOH
0.001751mol NaOH/17.14mL (1000mL/1L) = 0.1022M



Trial 4:

0.3292g KHP(1mol KHP/204.22g KHP) = 0.001612mol KHP = 0.001612mol NaOH
0.001612mol NaOH/17.14mL (1000mL/1L) = 0.1174M



Overall:
Average M NaOH: (.1156 + 0.1151 + .1174)/3 = 0.1160M
Standard Deviation = 0.0012M
CV = 0.0012M/0.1160M x 100 = 1.0%

Additional Comments

- Trial 3 was suspect so trial 4 was run and the data from trail 3 was dropped.
- Good precision

Titration of 0.1160M standardized NaOH with Unknow Diprotic Acid F

Refill burette with standardized NaOH solution

- Average molarity from standardization is 0.1160M

Prep flask of unknown acid

- Between .13-.17 g of acid added to each flask
- ~30mL of water added to each flask
- 2 drops of indicator added to each flask
- Swirled to mix
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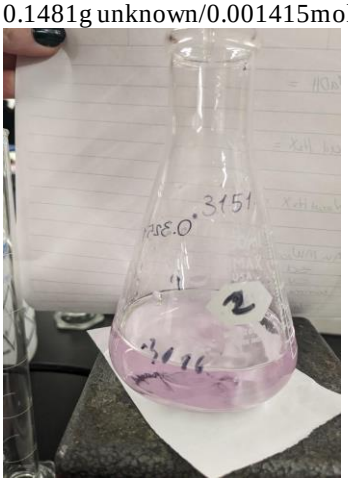
Titration of unknow diprotic acid to pink end point

- Titrant standardized 0.1160M NaOH
- Analyte unknown diprotic acid F
- Run off ~15mL

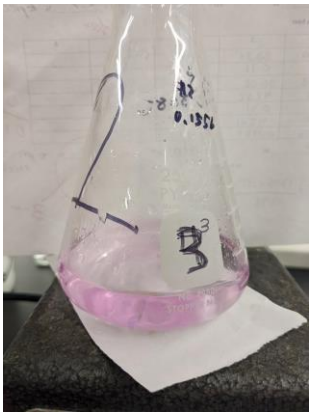
	Trial 1	Trial 2	Trial 3
Mass of Unknow F(g)	0.1481	0.1507	0.1398
Initial NaOH(mL)	0.11	0.31	0.60
Final NaOH(mL)	24.51	24.40	23.75
Total NaOH(mL)	24.40	24.09	23.15
Color	Pale Pink	Pale Pink	Pale Pink
Mol of NaOH	0.002830	0.002794	0.002685
Mol of Acid	0.001415	0.001397	0.001343
MW of Acid	104.7	107.9	104.1

Calculation for MW of unknow diprotic base

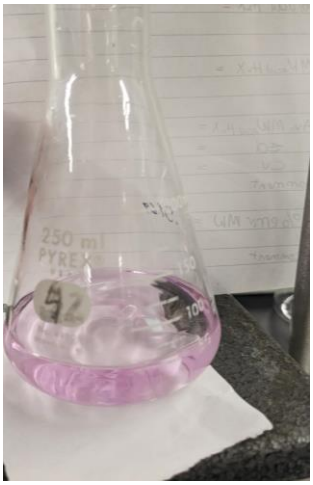
Trial 1:
24.40mL NaOH (1L/1000mL)(0.1160mol/1L) = 0.002830 mol NaOH
0.002830 mol NaOH(1 mol unknown/2mol NaOH) = 0.001415 unknown
0.1481g unknown/0.001415mol unknow = 104.7g/mol



Trial 2:
24.09mL NaOH (1L/1000mL)(0.1160mol/1L) = 0.002794 mol NaOH
0.002794 mol NaOH(1 mol unknown/2mol NaOH) = 0.001397 mol unknown
0.1507g/0.001397mol = 107.9g/mol



Trial 3:
23.15mL NaOH (1L/1000mL)(0.1160mol/1L) = 0.002685mol NaOH
0.002685 mol NaOH(1 mol unknown/2mol NaOH) = 0.001343 mol unknown
0.1398g/0.001343mol = 104.1g/mol



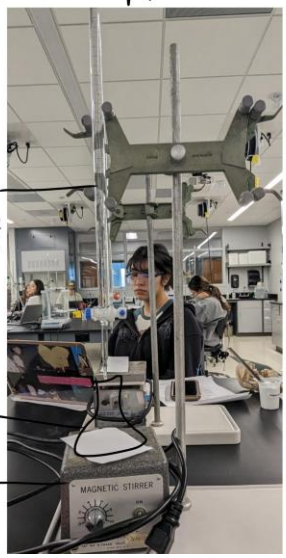
Overall:
Average mol of NaOH = 0.002770 mol
Average mol of unknown acid = 0.001385 mol
Average MW of unknown = 105.6 g/mol
Standard Deviation = 2.0 g/mol 1 place after decimat to match value
CV = 2.049/105.6 x 100 = 1.940% 1.9% 2sfs
Percent Error = (105.6-104.1)/104.1 x 100 = 1.4%

Additional Comments:

- Trial 2 is slightly suspect
- Good precision (CV)
- Good accuracy (percent error)
- High accuracy suggest high accuracy in standardization

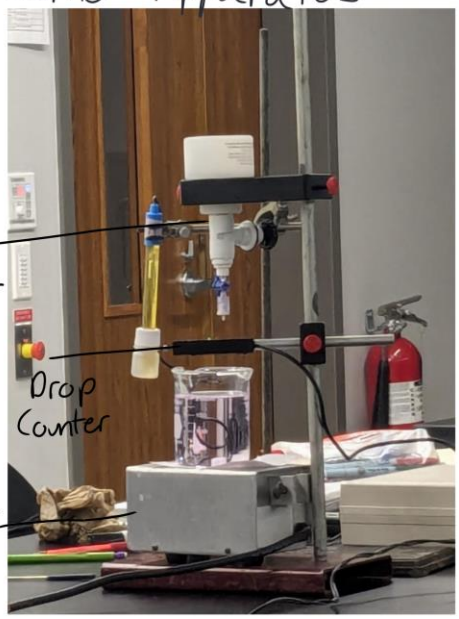
Balanced Equation-Acid name?
$H_2C_3H_2O_4(aq) + NaOH(aq) \rightarrow NaHC_3H_2O_4(aq) + H_2O(l)$
$NaHC_3H_2O_4(aq) + NaOH(aq) \rightarrow Na_2C_3H_2O_4(aq) + H_2O(l)$
Net equation: $H_2C_3H_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_3H_2O_4(aq) + 2H_2O(l)$

Titration apparatus

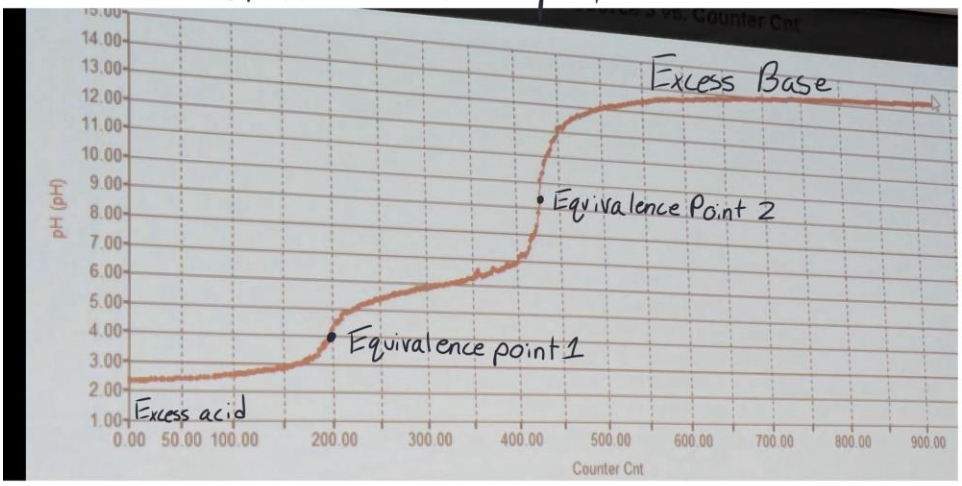


Demo:

Demo Apparatus



Demo Graph



- Acid is diprotic therefore it has 2 equivalence points
- First point is where first H atom/ proton is removed
- Second is where second H atom/ proton is removed