# The equilibrium constant of an ester hydrolysis reaction

The Equilibrium Constant of an Ester Hydrolysis Reaction Abstract: The results from this experiment show four different Kc equilibrium constants of: . 1522 for bottle two, . 1853 for bottle three, . 2094 for bottle four, and . 2678 for bottle five. The average Kc value came out to be . 2037 for all four bottles. Purpose: The purpose of this lab is to determine the equilibrium concentrations of an organic acid, an alcohol, an ester, and water in four bottles with varying measurements of each compound in of the four solutions. Once the concentrations are determined, one is then to discover the Kc, equilibrium constant, of those solutions by dividing the concentrations of alcohol and acid by the concentrations of ester and water. Methods/Procedure: First begin by mixing up and standardizing a 500mL solution of NaOH to titrate. For each of the six bottles, measure the directed amounts of ester, water, alcohol, and HCl. The bottles of different solutions will be left to come to equilibrium for two weeks. Once the NaOH is standardized, the solutions in the bottles have come to equilibrium, and a molarity is calculated, use the molarity of NaOH to discover how many mols were used to neutralize the solutions in each bottle. Once all of the calculations are complete, use an ICE chart to discover the mols of ester, water, acid, and alcohol at equilibrium to then calculate the Kc for each bottle. After a Kc has been calculated for all bottles, the last step is to determine an average Kc for all of the solutions. Calculations/Results: Grams of KHP needed: . 7mol x 35ml x 1molKHP x 204gKHP1000ml x 1 x 1molNaOH x 1molKHP= 5. 00gKHP Grams of NaOH: . 7molNaOH x . 500L x 1mol 1L x 1 x 40g~14gNaOH Mass of dish: 1. 80g Mass of bottle 1: 17. 1145g Mass of HCl 1: 4. 8778g Mass of NaOH 14. 0g Mass of bottle 1A: 17. 3521g Mass of HCl 1A: 5. 2319g Mass of dish: 2. 0097g Mass of dish and KHP: 6. 0548g Mass of

KHP: 5. 0378g mL of NaOH used to neutralize KHP: 1. 36. 90mL 2. 30. 80mL 3. 36. 40mL g of KHP: 1. 5. 0378g 2. 4. 2074g 3. 4. 9722g Molarity of NaOH: . 6690M | . 6689M | Avg M: . 6688M NaOH | 5. 0378gKHP x 1molKHP x 1molNaOH x 1 x 1000mL1 x 204. 2g x 1molKHP x 36. 90mL x 1L=. 6686M mL of NaOH used: 1A: 6. 20mL — 24. 90mL = 18. 70mL | 1: 17. 00mL | 2: 60. 54mL | 3: 58. 60mL | 4: 45. 55mL | 5: 40. 75mL | Ethanol: Water: Ethyl Acetate: Density: . 7893g/mL Density: . 9982g/mL Density: . 9003g/mL Molar Mass: 46. 07g/mol Molar Mass: 18. 02g/mol Molar Mass: 88. 11g/mol mL of solutions in each bottle: Bottle # | 3M HCl (mL) | H2O (mL) | Ester (mL) | Alcohol (mL) | 1 | 5. 00 | 5. 00 | 0 | 0 | 1A | 5. 00 | 5. 00 | 0 | 0 | 2 | 5. 00 | 0 | 5. 00 | 0 | 3 | 5. 00 | 1. 00 | 4. 00 | 0 | 4 | 5. 00 | 3. 00 | 2. 20 | 0 | 5 | 5. 00 | 2. 00 | 2. 00 | 1. 00 | Bottles 1 and 1A M HCl: 17. 00mLNaOH x . 6688molNaOH x 1 molHCl x 11 x 1000ml x 1molNaOH x . 005LHCl= 2. 27MHCL x . 005L= . 01137molHCl . 01251 molHCl Average mol HCl of bottles 1 and 1A: (. 01251mol + . 01137mol)/2 = . 01194molHCl Mol NaOH for bottles 2-5: . 6688MNaOH x 1L x 60. 54mLNaOH1L x 1000mL x 1= . 04049molNaOH . 03919molNaOH . 03046molNaOH . 02725molNaOH Density of HCl: 5. 2319gHCl x 11 x 5. 00mL= 1. 046g/mLHCl Grams of HCl and H2O: 1. 046gHCl x 5. 00mLH2O1mL= 5. 230gHCl+H20 Grams of HCl: . 01194molHCl x 36. 54gHCl1 mol HCl= . 4352gHCl Grams of HCl and H2O — Grams of HCl: 5. 230gHCl+H2O - . 4352gHCl = 4. 794gH2O from 5. 00mL of HCl in bottles 1-5 Grams of H2O made + grams H2O given for bottles 2-5: 4. 794gH2O + 0. 00mLH2O x . 9982gH2O/mL = 4. 794gH2O 5. 792gH2O 7. 789gH2O 6. 790gH2O Grams to mols of H2O for bottles 2-5: 4. 794gH2O x 1molH2O1 x 18. 02gH2O= . 2661molH2O . 3214molH2O . 4322molH2O . 3768molH2O Mols of ester for bottles 2-5: 5. 00mLester x . 9003gester x 1mol ester1 x

1mL x 88. 11gester= . 05109mols ester . 4087mols ester . 02248mols ester . 02044mols ester Mols of acid for bottles 2-5: 60. 54mLNaOH x 1L x . 6688molNaOH x 1molacid1 x 1000mL x 1L x 1molNaOH x 1= . 04049molacid . 03919molacid . 03046molacid . 02725molacid Total mols of acid — mols HCl for bottles 2-5: . 04049mol total acid - . 01194mol HCl = . 02855mol organic acid . 02725mol organic acid . 01852mol organic acid . 01531mol organic acid Mols of alcohol for bottle 5: 1. 00mLalcohol x . 7893galcohol x 1 mol alcohol1 x 1mL x 46. 07galcohol= . 01713mol alcohol Ice Charts for bottles 2-5: ESTER (mol) | WATER (mol) | ACID (mol) | ALCOHOL (mol) | I: . 05109 | . 2661 | 0 | 0 | C: -. 02855 | -. 02855 | -. 02855 | -. 02855 | E: . 02254 | . 2376 | . 02855 | . 02855 | ESTER (mol) | WATER (mol) | ACID (mol) | ALCOHOL (mol) | I: . 04087 | . 3214 | 0 | 0 | C: -. 02725 | -. 02725 | -. 02725 | -. 02725 | E: . 01362 | . 2942 | . 02725 | . 02725 | ESTER (mol) | WATER (mol) | ACID (mol) | ALCOHOL (mol) | I: . 02248 | . 4322 | 0 | 0 | C: -. 01852 | -. 01852 | -. 01852 | -. 01852 | E: . 00396 | . 4137 | . 01852 | . 01852 | ESTER (mol) | WATER (mol) | ACID (mol) | ALCOHOL (mol) | I: . 02044 | . 3768 | 0 | . 01713 | C:-. 01531 | -. 01531 | -. 01531 | . 01531 | E: . 00513 | . 3615 | . 01531 | . 03244 | Kc for bottles 2-5: Kc=. 02855[. 02855]. 0254[. 2376]= . 1522 . 1853 . 2094 . 2678 Avg Kc: . 1522 + . 1853 +. 2094 + . 2678 = . 8147 . 8147/4 = . 2037 Discussion: A known error in this experiment with this data is the mass of hydrochloric acid measured for bottle 1. The mass was below 5 grams (4. 8778g) which threw the calculations off. To compensate for the poor data, an average of the two masses of hydrochloric acid was taken, and then the number of moles was found to get a better approximation of what the number of moles should be. Another possible error in this experiment was not having adequate time for the solutions to equilibrium completely. If the solutions had not fully reached equilibrium the equilibrium constant would be off for whichever solutions, if not all, that had not come to equilibrium. The Kc values were all approximately one tenth off of each other. In theory, the Kc values should all be the same which indicates that there is a high probability that the solutions had not fully reached equilibrium. In conclusion, the results would have been closer and more exact had the solutions had more time to come to equilibrium as well as if the mass of hydrochloric acid was closer to where it should have been.