DATE: NAME: CLASS:

CHAPTER 16	Thought Lab 16.1: Finding an Equilibrium Law	BLM 16.3.1
HANDOUT		

Ethyl ethanoate is an important ester. It is used as a solvent in paints, adhesives, and nail polish remover. Ethanoic acid reacts with ethanol to form ethyl ethanoate and water:

$$CH_3COOH(aq) + CH_3CH_2OH(aq) \leftrightarrow CH_3COOCH_2CH_3(aq) + H_2O(aq)$$

This is a homogeneous equilibrium system in which each substance takes part in the reaction and forms a solution. The reaction is catalyzed by hydrochloric acid.

A group of students investigated this reaction by using the following method:

Procedure

1. A known mass of ethanoic acid was placed in a flask. Then some ethanol was measured and added to the flask.
2. A measured volume of hydrochloric acid of known concentration was added to the mixture of ethanoic acid and ethanol.
3. The flask was sealed with a stopper and placed in a water bath to keep the temperature of the mixture constant at 20 °C. The flask was left for a week to allow the mixture to reach equilibrium.
4. After leaving the flask for a week, the volume of the solution was measured. Then the solution was titrated against a freshly prepared standardized solution of sodium hydroxide, using phenolphthalein as an indicator.

Analysis

1. Using the titration data, the total amount of ethanoic acid and hydrochloric acid present at equilibrium was calculated. Because it is a catalyst, the amount of hydrochloric acid remains constant throughout the reaction. By subtracting the amount of hydrochloric acid from the total amount of acid, the amount of ethanoic acid at equilibrium was determined. The following data were obtained from five different experiments:

The Equilibrium Reaction to Form Ethyl Ethanoate at 20 °C

Experiment	Initial $CH_3COOH(aq)$ (mol)	Initial $CH_3CH_2OH(aq)$ (mol)	Equilibrium $CH_3COOH(aq)$ (mol)	Total volume (mL)
1	0.220	0.114	0.125	38.1
2	0.184	0.115	0.0917	40.3
3	0.152	0.121	0.0631	39.4
4	0.214	0.132	0.110	42.6
5	0.233	0.137	0.122	41.5

2. In a spreadsheet program, enter the data from the table and calculate the initial $[CH_3COOH(aq)]$, the initial $[CH_3CH_2OH(aq)]$, and the equilibrium $[CH_3COOH(aq)]$.
3. The ICE table for Experiment 1 is partially filled in on the following page. One more digit has been carried to reduce rounding error. Check that your spreadsheet returns the values shown in the ICE table for Experiment 1.

Thought Lab 16.1: Finding an Equilibrium Law (continued)

	$CH_3COOH(aq) + CH_3CH_2OH(aq) \leftrightarrow CH_3COOCH_2CH_3(aq) + H_2O(aq)$			
	$[CH_3COOH(aq)]$ (mol/L)	$[CH_3CH_2OH(aq)]$ (mol/L)	$[CH_3COOCH_2CH_3(aq)]$ (mol/L)	$[H_2O(aq)]$ (mol/L)
Initial	5.774	2.992	0	0
Change				
Equilibrium	3.281			

4. Add calculations to your spreadsheet program to calculate the terms missing from the ICE table for each of the five experiments.

5. Use your spreadsheet program to calculate the equilibrium constant, K_c, for each of the five experiments.

6. The five determinations of K_c should be the same *within experimental error*. Comment on the results of the experiments.

7. Use your spreadsheet program to investigate other mathematical relationships among the equilibrium concentrations. Does one of these relationships give a more constant value than the relationship you used to calculate K_c?