Experiment No.:

Determine the Rate constant (Velocity Constant) for the Acid Catalyzed Hydrolysis of Methylacetate at Laboratory Temperature.

Requirement: Methylacetate, N/2 HCl solution, N/15 NaOH solution, Phenolphthalein (indicator), Ice cold water, 2ml pipette, Burette, Conical flask, Conical flask with stopper (Erlenmeyer flask), 50ml measuring cylinder, 150ml & 250ml beaker.

Theory: Methylacetate hydrolyses in presence of an acid (acts as catalyst) and produces acetic acid and methyl alcohol.

$$CH_3COOCH_3 + H_2O \xrightarrow{H^+} CH_3COOH + CH_3OH$$

Velocity of the reaction, $v = \frac{dx}{dt} = k^{'}[CH_3COOCH_3][H_2O]$

$$= k[CH_3COOCH_3] \qquad \text{where, } k = k^{'}[H_2O]$$

(Note: water is present in large excess, water concentration practically remain constant throughout the reaction.)

In the above equation rate of reaction is determined by the first power of the concentration (of ester). Hence, the reaction is called first order reaction. It is also known as *pseudo-unimolecular* reaction.

Let, a = initial concentration of ester (at t = 0) of the above reaction.
(a-x) = Concentration of ester remaining at time t.
The rate is represented by

$$v = \frac{dx}{dt} = k\ (a - x)$$

On integration, $k = \frac{2.303}{t}\log\frac{a}{(a-x)}$

This reaction was followed by quenching an aliquot of the reaction mixture at different time and titrating the total acid (both acetic acid formed and the N/2 HCl acid taken originally) by a standard solution of N/15 NaOH.

If V_0, V_t and V_∞ are the volumes of N/15 NaOH consumed to neutralize the acids of a given volume of the reaction mixture at the beginning (t = 0), at time t, and at the end ($t = \infty$) of the reaction respectively, the rate constant of the reaction can be expressed as

$$k = \frac{2.303}{t}\log\frac{V_\infty - V_0}{V_\infty - V_t} \qquad \text{---(1)}$$

where V_0= titration reading at time t=0, at time t, and at $t = \infty$.

because $\left(V_\infty - V_0\right)$ is proportional to the concentration of the total acetic acid formed or the conc. of ester in the beginning of the reaction, *a* and $\left(V_\infty - V_t\right)$ is proportional to the concentration of the unreacted ester (*a*-*x*) at time *t*. The *equation 1* can be rearranged as follows

$$\log \frac{V_\infty - V_0}{V_\infty - V_t} = \frac{k}{2.303} t \qquad \text{[Note the similarity with y = mx + c (=0)]}$$

The velocity constant was determined from the slope (m $= \frac{k}{2.303}$) of the graph of $\log \frac{V_\infty - V_0}{V_\infty - V_t}$ vs *t* as well as directly using the equation 1 at each time.

[An example of the graph was given at the end of this note.]

Procedure: N/15 NaOH solution was taken in the burette while 50ml N/2 HCl solution was taken in a stoppered conical flask using a measuring cylinder. 2ml methylacetate was pipetted out and poured into the conical flask and was shaked well. As soon as the ester was poured, the time count starts. 2ml of the reaction mixture was pipetted out immediately and was added to 25 ml of ice cold water in a conical flask (i.e., quenching of the reaction). 2-3 drops of phenolphthalein indicator was added in that quenched solution and was titrated against N/15 NaOH solution. Titration was completed as soon as possible. The burette reading, so obtained, was considered as V_0 (since t = 0 min, *assumed*). When the stopwatch was seen to be at 5 min, again 2 ml of the reaction mixture was quenched and the titration was done following the same procedure. The burette reading so obtained was considered as V_5 (since t = 5 min). The same procedure was repeated at t = 10, 20, 30, and 40 min to get the corresponding burette readings of V_{10}, V_{20}, V_{30}, and V_{40} respectively [*Note: any other convenient time gap may be used*]. Finally, the reaction mixture was heated at 60-80^o C for 20min (**caution**: *Do not boil the solution. Do not stoppered the conical tightly, use a paper strip to avoid stuck*). It was cooled down to room temperature. 2ml of this mixture was taken out in the conical and was titrated against the N/15 NaOH as described earlier. The reading was noted as V_∞.

Observation and Calculation:

Lab. Temperature: ^{o}C
$V_0 =$ ml
$V_\infty =$ ml
$(V_\infty - V_0) =$ ml

Table. Burette reading at different times and corresponding calculated rate constant.

Sl. no.	Time (t) /min	Burette Reading (V_t)	$(V_\infty - V_t)$	$\frac{V_\infty - V_0}{V_\infty - V_t}$	$\log \frac{V_\infty - V_0}{V_\infty - V_t}$	$k = \frac{2.303}{t} \log \frac{V_\infty - V_0}{V_\infty - V_t}$ min^{-1}
1.	5					
2.	10					
3.	20					
4.	30					
5.	40					

From the Table : $k_{avg} =$

From the Graph **:** k_{Graph} = slope x 2.303 min^{-1}

Result: Rate constant / Velocity constant for the acid catalyzed hydrolysis of the methylacetate at laboratory temperature (^{o}C) was found to be:

i) From table, k_{avg} = min^{-1}

ii) From Graph, k_{Graph} = min^{-1}

Experiment No.:

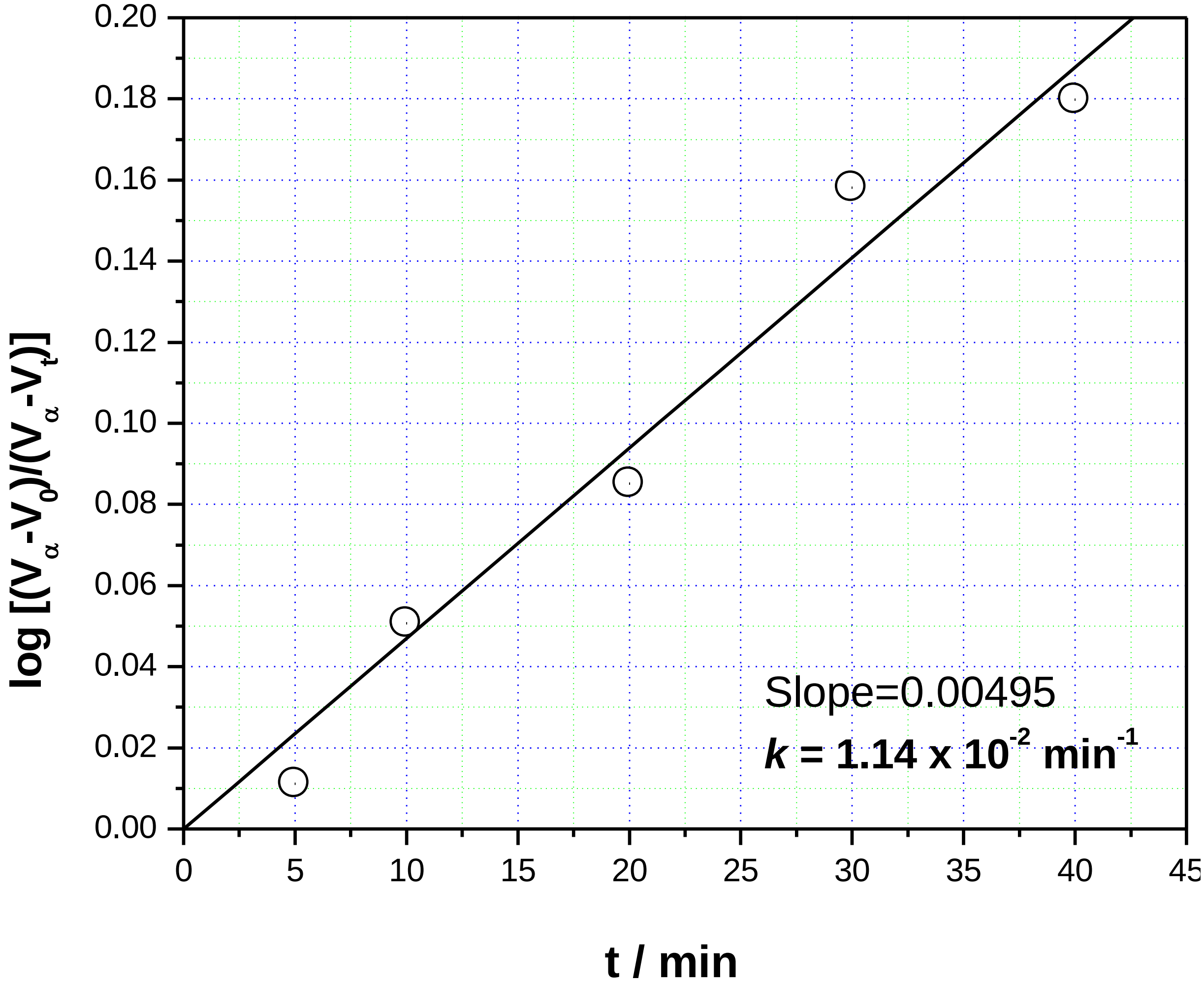
Determine the rate constant and *half-life* for the acid catalyzed hydrolysis of methylacetate at laboratory temperature.

At *t= t/2* (i.e., half life period: half of the reactant converted to the product)
x= a/2

$$k = \frac{2.303}{t} \log \frac{a}{(a-x)} = \frac{2.303}{t_{\frac{1}{2}}} \log \frac{a}{a - \frac{a}{2}} = \frac{2.303}{t_{\frac{1}{2}}} \log 2$$

$$t_{\frac{1}{2}} = \frac{0.693}{k} min^{-1}$$

Example **of a typical Graph for this experiment:**



Student 3:

vinf	V0sep	V0inst	v	t	vinf-vt	vinf-vos	vinf-v0ins	log-sep	log-ins
28	16	16.2	16.5	5	11.5	12	11.8	0.018483	0.011184
			17.5	10	10.5			0.057992	0.050693
			18.3	20	9.7			0.09241	0.08511
			19.8	30	8.2			0.165367	0.158068
			20.2	40	7.8			0.187087	0.179787