Kinetics of Iodination of Propanone by Colorimetry

Student Handout

Purpose

To determine the rate equation of the reaction between acidified propanone solution and iodine.

Introduction

As the following reaction proceeds,

$$\underset{\text{colourless}}{CH_3COCH_3(aq)} + \underset{\text{(brown/yellow)}}{I_2(aq)} \longrightarrow \underset{\text{colourless}}{CH_3COCH_2I(aq)} + \underset{\text{colourless}}{H^+(aq)} + I^-(aq)$$

the concentration of iodine decreases and the brown/yellow colour intensity of the reacting solution also decreases. The change in colour intensity allows the use of colorimetry to follow the reaction kinetics.

For dilute solutions, absorbance is proportional to concentration. Decrease in concentration of species can be measured by the change in absorbance. Relative rate of disappearance of iodine, in terms of decrease in absorbance and ***not in terms of actual decrease in concentration of iodine***, is measured from the absorbance vs time plot. This avoids the time-consuming conversion to concentration units using a calibration curve.

Order of reaction with respect to each reactant is determined by separately doubling the concentrations of each of $CH_3COCH_3(aq)$, $H^+(aq)$ and $I_2(aq)$. A first order reaction with respect to $CH_3COCH_3(aq)$ is confirmed when, while keeping the concentrations of $I_2(aq)$ and $H^+(aq)$ constant, the initial rate of decrease in concentration of $I_2(aq)$ (or the initial rate of decrease in absorbance) doubles as the concentration of $CH_3COCH_3(aq)$ is doubled.

Safety

Avoid skin contact with chemicals.

Materials and Apparatus

1 M sulphuric acid, 1 M propanone solution

0.02 M iodine solution, deionised water, a datalogger with colorimeter accessories, computer, micro-tip plastic pipette, 5 cm^3 graduated pipette.

Experimental Procedures

Part A: Calibration of the colorimeter

1. Set up the interface box and connect it to the computer. Calibrate the colorimeter as described in the manual that accompanies with the commercial datalogger. A blue filter should be used for the experiment.

Part B: Kinetic runs

2. Start the program for colorimetry with graphical display. Choose the option for transmittance and a time interval of 10 minutes.
3. Using a clean graduated pipette, transfer 0.75 cm^3 of 1 M propanone and 0.75 cm^3 1 M sulphuric acid into a clean cuvette. Add 1.50 cm^3 of deionised water. Mix the solution well by capping the cuvette and inverting it upside down for three times.
4. Uncap the cuvette, and using a micro-tip plastic pipette, quickly add 30 drops of 0.02 M iodine solution. Cap the cuvette, lower it into the cell compartment of the colorimeter and start recording at the same time.
5. Stop recording when the transmittance signal flattens.
6. Convert the OY axis to absorbance scale and measure the initial rate of decrease in absorbance according to the software manual. Save the data file.
7. Repeat steps (3) to (6) with other runs according to the following scheme.

Run	Vol. of 1 M Propanone /cm^3	Vol. of 1 M sulphuric acid/cm^3	Vol. of deionised water/cm^3	No. of drops of 0.02 M I_2(aq)	No. of drops of deionised water
1	0.75	0.75	1.50	30	-
2	1.50	0.75	0.75	30	-
3	0.75	1.50	0.75	30	-
4	0.75	0.75	1.50	15	15

(Adjust volume or no. of drops accordingly to size of cuvette used)

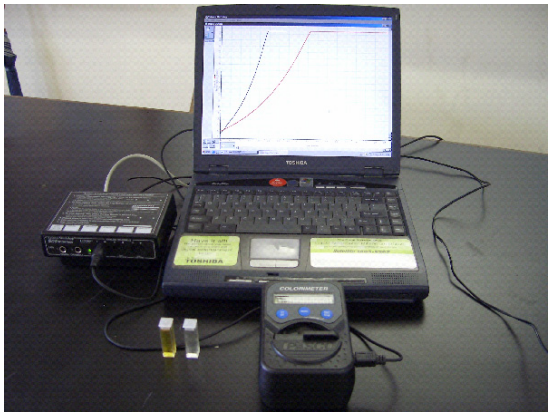

Fig. 1: Setup for colorimetric measurement.

Treatment of Data

From the absorbance vs time plot, calculate the relative initial rate of decrease in concentration of iodine for the following cases:

1. Doubling the concentration of propanone

Run	Rel. concentration of propanone	Initial rate of decrease in conc. of I_2(aq)	Rel. initial rate of decrease in conc. of I_2(aq)	Order w.r.t. propanone(aq)
1	1			
2	2			

2. Doubling the concentration of sulphuric acid

Run	Rel. concentration of H^+(aq)	Initial rate of decrease in conc. of I_2(aq)	Rel. initial rate of decrease in conc. of I_2(aq)	Order w.r.t. H^+(aq)
1	1			
3	2			

3. Doubling the concentration of iodine solution.

Run	Rel. concentration of I_2(aq)	Initial rate of decrease in conc. of I_2(aq)	Rel. initial rate of decrease in conc. of I_2(aq)	Order w.r.t. I_2(aq)
4	1			
1	2			

Discussion Questions

1. Deduce the kinetic order of the reaction w.r.t. (i) propanone, (ii) H^+(aq) and (iii) I_2(aq), and hence the experimental rate equation for the reaction.

2. The role played by H^+(aq) in the reaction is suggested to involve the formation of a –C(OH)=C- group (enol) from the –CO- group (keto) [ketoenol tautomerism]. Propose a mechanism for the reaction that agrees with the experimental rate equation.