EXPERIMENT-8

(a) To study the effect of concentration on the rate of reaction between sodium thiosulphate and hydrochloric acid.

(b) To study the effect of temperature on the rate of reaction between sodium thiosulphate and hydrochloric acid.

8.1 OBJECTIVES

After performing this experiment, you should be able to :

- *observe the effect of concentration of reactants on rates of reactions;*
- *predict the effect of concentration of reactants on rates of reactions*
- *observe the effect of temperature on rates of reactions*
- *predict the effect of temperature on rates of reactions.*

8.2 WHAT YOU SHOULD KNOW

Concentration and temperature are two important factors which affect the rate of a reaction. Effect of concentration on rate of a reaction is given by its rate law.

For a general reaction

$$aA + bB \longrightarrow \text{Products}$$

The rate law may be written as, rate = $k [A]^x [B]^y$

Here, x and y are the orders of the reaction with respect to reactants A and B respectively. The overall order, n, is given by

$$n = x + y$$

and k is the rate constant of the reaction.

Generally, x and y are positive integers. However, in some cases they may be fractions or zero. Thus generally speaking, on increasing the concentration of a reactant, the rate of reaction increases. The rate of reaction also depends upon the temperature. Arrhenius equation gives the relationship between the two

$$k = A.\ e^{-Ea/RT}$$

where, k is the rate constant of the reaction at temperature T. A and Ea are constants for a given reaction. While A is known as Arrhenius factor and Ea as activation energy. Activation energy is the minimum energy which the reactant molecules must possess over and above their average energy in order to undergo chemical change. On raising the temperature, more reactant molecules possess sufficient energy required for reaction. Hence, the rate of the reaction increases.

The reaction between sodium thiosulphate and hydrochloric acid occurs according to the following equation,

$$Na_2S_2O_3\,(aq) + 2HCl\,(aq) \longrightarrow 2NaCl\,(aq) + H_2O\,(l) + SO_2\,(g) + S\,(s)$$

As the reaction proceeds, the amount of precipitated sulphur increases, the solution becomes increasingly turbid and at a certain stage it becomes opaque. This stage can be fairly judged accurately by a simple method. The flask containing the reaction mixture is kept on a sheet of white paper on which a cross is marked in ink and when the reaction mixture becomes opaque, the cross is no longer visible. Rate of the reaction is inversely proportional to the time interval between the start of the reaction and the disappearance of the cross mark.

Effect of concentration of each reactant can be studied by changing the concentration of one reactant while keeping that of the other constant. The time for disappearance of cross mark (×) is noted in each case. The inverse values of the time intervals are compared. Effect of temperature can be studied by starting the reaction with the same concentrations of both the reactants at different temperatures. The inverse values of the time intervals for the cross mark to disappear are compared.

8.3 MATERIALS REQUIRED

(1) Apparatus	(2) Chemicals
Four 150 ml conical flasks, 50 ml measuring cylinder, Thermometer, – 10 to 110°C Stop watch Bunsen burner Tripod stand Wire gauze Sheet of plain white paper	Dilute HCl – 1M Sodium thiosulphate solution – 0.1M

8.4 HOW TO PERFORM THE EXPERIMENT

(a) Effect of Concentration

Take three clean and dry conical flasks and mark them 1, 2 and 3. If necesary, clean the flasks with dilute nitric acid and then wash with water thoroughly before using them. With the help of measuring cylinder, take 30 ml–distilled water in the conical flask 1 and 20 ml–each in flask 2 and flask 3. Rinse the measuring cylinder with the solution of sodium thiosulphate and add 10 ml of it each in flask 1 and flask 2 and 20ml–in the flask 3. Using a ball point pen, mark a cross on a sheet of plain white paper, lay it on the table and keep the flask 1 on it, so that it covers the cross – mark. Make sure that the flask is

absolutely dry from outside and base, before keeping it on paper. If necessary, wipe it dry with a piece of filter paper. Wash the measuring cylinder with water and rinse it with hydrochloric acid. Now add 10 ml of hydrochloric acid to the flask 1, swirl it to mix the solutions and simultaneously start the stop watch. Keep the flask back on the white paper. Observe the cross mark through the solution and stop the watch as soon as it disappears. Record the time interval and its inverse in the Table 8.1 (given in section 8.5) and reset the zero of the stop watch for next reading. Repeat the procedure, first, using flask 2 and adding 20 ml hydrochloric acid to it and then with flask 3 and adding 10 mL hydrochloric acid. Record the readings in Table 8.1.

(b) Effect of Temperature

Take three clean and dry conical flasks and mark them 1, 2 and 3. If necessary, before using, clean them with dilute nitric acid and wash with water thoroughly. Using a clean measuring cylinder take 30 mL distilled water in each flask. Rinse the measuring cylinder with sodium thiosulphate solution and add 10mL of it in each of these three conical flasks. Using a ball–point pen, make a crossmark on a plain white sheet of paper and lay it on table. Wash the measuring cylinder with water and rinse with hydrochloric acid. Take another conical flask (other than the three marked flasks) and take 10 mL hydrochloric acid in it using the measuring cylinder.

Heat both the flasks (flask No. 1 containing $Na_2S_2O_3$ and the other containing HCl) to a temperature of about 40° C separately on two tripod stands with wire gauze on them. Place the flask 1 on the sheet of white paper covering the cross–mark. Quickly pour the hot HCl solution into the flask 1. Mix the solutions by swirlling and start the stop watch simultaneously. Keep it back on the white sheet of paper. Measure the temperature of the mixture solution and record in table 8.2 (given in section 8.5). Observe the cross mark through the solution and stop the watch as soon as it disappears. Record the time interval and its inverse in Table 8.2. Reset the zero of the stop watch for next reading. Repeat this procedure two more times. First time use the flask 2, and heat the solutions to about 50°C. Second time use flask 3 and heat the solutions to about 60° C. Record the observations in table 8.2.

8.5 PRECAUTIONS

1. All conical flasks should be of same capacity and total volume of reaction mixture should be same for each observation.

2. Same sheet of white paper with cross marked on it should be used in all the observations.

3. Start the stop watch as soon as the solutions are mixed. Stop the stop watch as soon as the cross – mark just disappears.

4. While placing on white paper, the base and outer surface of the conical flask should be absolutely dry, else, the white paper or the cross marked on it would be spoiled.

5. Wash the conical flasks immediately after taking the reading with the help of dilute HNO_3 first and then with water. If not washed immediately, the sulphur starts depositing on the walls of the flask and makes the cleaning more difficult.

8.6 OBSERVATIONS

Table 8.1: Effect of concentration on rate of reaction between HCl and $Na_2S_2O_3$

S. No.	Volume of				Initial Conc. of		Time	Time
	Water	0.1 M $Na_2S_2O_3$	1 M HCl	Total	$Na_2S_2O_3$	HCl		inverse
	ml	ml	ml	ml	mol l^{-1}	mol l^{-1}	s	s^{-1}
1.	30	10	10	50	..	...	...	...
2.	20	10	20	50	...	...	...	...
3.	20	20	10	50	...	...	...	...

Table 8.2 : Effect of temperature on rate of reaction between HCl and $Na_2S_2O_3$

S. No.	Volume of				Temperature	Time	Time
	0.1 M $Na_2S_2O_3$	Water	1 MHCl	Total			inverse
	mL	mL	mL	mL	°C	s	s-1
1.	10	30	10	50	.....	...	...
2.	10	30	10	50	.....	...	...
3.	10	30	10	50	.....	...	...

8.7 CONCLUSION

1. The rate of reaction increases / decreases / remains unchanged when concentration of either sodium thiosulphate or HCl is increased while keeping the other constant.

2. The rate of the reaction increases / decreases / remains unchanged when it is carried out at higher temperature while keeping all other factors like concentretion constant.

8.8 CHECK YOUR UNDERSTANDING

1. *What are the initial concentrations of sodium thiosulphate and HCl in a solution obtained by mixing10 Ml of 0.1 M $Na_2S_2O_3$, 20 ml of 1M HCl and 20 ml–water. Assume that no reaction has started as yet.*

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2. *While studying the effect of temperature on the rate of reaction, same volumes of sodium thiosulphate and HCl solutions are used in each experiment. Why it is so ?*

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3. *Why does increase in temperature generally increases the rate of a reaction ?*

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4. What will be the effect of decrease in temperature on rates of reactions which occur in biological processes? Give one example where it is used.

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5. Sometimes the solution of sodium thioulphate starts becoming turbid even before adding HCl to it. What can be its reason ?

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8.9 NOTE FOR THE TEACHER

Emphasize the importance of proper cleaning of conical flasks, specially after the flask has been used once. The students may be told that sulphur precipitated in the reaction sticks to the walls of the flask and is not easily removable. Therefore, washing should be done immediately after taking the reading. If simple washing by water does not remove the sulphur coating, washing may first be done with very dilute HNO_3 and then with water. Washing with water must be thorough so that HCl (used in the experiment) or HNO_3 (used for washing) are completely washed away. Otherwise, these will start the reaction in the next reading even before HCl is added.

8.10CHECK YOUR ANSWERS

Ans.1 :Final concentrations can be calculated by using the relation $M_1 V_1 = M_2 V_2$ where M_1 and V_1 are the molarity and volume of the initial solution and M_2 and V_2 are the molarity and volume of the final solution obtained after dilution.

(a) Molarity of $Na_2S_2O_3$

$M_1 = 0.1$ M $\quad V_2 = 10 + 20 + 20 = 50$ ml

$V_1 = 10$ ml $\quad M_2 = ?$

$$M_2 = \frac{M_1 V_1}{V_2} = \frac{0.1 \times 10}{50}$$

$= 0.02$ M

(b) Molarity of HCl

$M_1 = 1$ M $\quad V_2 = 10 + 20 + 20 = 50$ cm^3

$V_1 = 20$ cm^3 $\quad M_2 = ?$

$$M_2 = \frac{M_1 V_1}{V_2} = \frac{1 \times 20}{50}$$

$= 0.4$ M

Ans.2: If different volumes of sodium thiosulphate or HCl solutions are used besides temperature, their concentrations would also be different in different observations. Now the rate of the reaction would be affected by both the factors, and not only by temperature alone which is the aim of the study.

Ans.3: On raising the temperature, more reactant molecules possess the sufficiently high energy to overcome the activation energy barrier of the reaction. This increases the rate of the reaction.

Ans.4: It will decrease the rate of reactions occurring in biological proceses. It is used in refrigeration or cold storage of food articles to increase their shelf life (or to keep them fresh for longer period of time) by slowing down the bacterial decay which occurs in them.

Ans.5: It can be due to improper washing of conical flask with some HCl (from the previous reading) or HNO_3 used for washing of the flask) still remaining in it. The acid left in conical flask reacts with sodium thiosulphate and the solution becomes turbid due to the formation of sulphur.