EXPERIMENT-7

To study the shift in equilibrium between ferric ions and thiocyanate ions by increasing/ decreasing the concentration of these ions.

7.1 OBJECTIVES

After performing this experiment, you should be able to :

- *perform dilution of the solutions using measuring cylinder ;*
- *compare the intensity of colours in two solutions visually ;*
- *predict the direction in which the equilibrium will shift if the concentration of any reactant is increased or decreased ;*
- *predict the direction in which the equilibrium will shift, if the concentration of any product is increased or decreased.*

7.2 WHAT YOU SHOULD KNOW

A reversible reaction never reaches the completion stage but results in an equilibrium state in which concentrations of all the reactants and products become constant. This equilibrium is dynamic in nature and it is the result of two opposite reactions occurring simultaneously and at the same rate. However, no 'net' change occurs in the system.

According to Le Chatelier's Principle "*when any system at equilibrium is disturbed by changing concentrations, temperature or pressure, the equilibrium shifts either in forward or backward direction and a 'net' change occurs in it so as to decrease the effect of the disturbing factor*".

Consider the following equilibrium

$$A+B \rightleftharpoons C+D$$

The equilibrium constant for it is given by

$$K=\frac{[C][D]}{[A][B]}$$

When concentration of A or B is increased, the equilibrium will shift in forward direction, so that some quantity of A and B is consumed and corresponding quantities of products C and D are formed. When concentration of A or B is decreased, the quilibrium will shift in backward direction. Now same quantity of C and D is consumed and corresponding quantities of reactants A and B are produced. Similarly when concentration of products C or D is increased, the equilibrium will shift in the backward direction and when it is decreased it will shift in the forward direction.

Ferric ions react with thiocyanate ions to form a blood red coloured complex, $[Fe(CNS)]^{2+}$, and the following equilibrium is established.

$$\underset{\text{pale yellow}}{Fe(aq)^{3+}} + \underset{\text{colourless}}{CNS^-(aq)} \rightleftharpoons \underset{\text{deep blood red}}{[Fe(CNS)]^{2+}(aq)}$$

The effect of change in concentration of Fe^{3+} or CNS^- ions on this equilibrium can be studied easily. If this equilibrium shifts in forward direction, more quantity of the complex will be formed and the colour of the solution will become more intense. Similarly, when the equilibrium shifts in backward direction, some quantity of the complex will break and the colour of the solution will become light.

7.3 MATERIALS REQUIRED

(1) Apparatus	(2) Chemicals
Test tube stand	0.02 M KCNS Solution
Test tubes - 5	0.02 M $Fe(NO_3)_3$ Solution
Measuring cylinder - 10 ml	
Measuring cylinder - 50 ml	
Wash bottle	
White glazed tile or a sheet of plain white paper.	

7.4 HOW TO PERFORM THE EXPERIMENT

1. Take five clean and dry test tubes, number them from 1 to 5 and keep them in a test tube stand. Mark the test tube number 3 as "Reference Tube".
2. Take 10ml Fe $(NO_3)_3$ solution (0.02 M) in a clean and dry 50 ml measuring cylinder. Fill it up with distilled water upto 40 ml mark and stir to mix. Take 5 ml of this diluted 0.005M Fe $(NO_3)_3$ solution in each of the five test tubes.
3. In a clean and dry 10 ml measuring cylinder take 10 ml KCNS solution (0.02 M). Out of it, add 5 mL solution to test tube, number 1.
4. The measuring cylinder now contains 5 ml of 0.02 M KCNS solution. Add distilled water to make the volume upto 10 ml mark in the measuring cylinder with a wash bottle and stir to mix. You get KCNS solution of 0.01 M concentration. Pour 5ml of 0.01 M KCNS solution into test tube number 2.
5. Add distilled water in the remaining solution to make the volume upto 10 ml which will give a solution 0.005 M and transfer 5 ml of this solution to test tube number 3.
6. Again add distilled water in the remaining solution in the test tube No. 1 to obtain a solution of 0.0025 M and transfer 5 Ml of solution to test tube number 4.

7. Similarly, in order to set a solution of 0.00125 Ml upto 10 mL in the first test tube by adding distilled water in it and transfer 5ml of it to the fifth test tube.

8. Shake all the five test tubes to mix the solutions and keep them back on test tube stand.

9. Compare the intensity of red colour in test tube number 1 with that in 'Reference Tube' (Number 3). For this purpose, hold the two tubes against white background of a glazed tile or a plain white paper. Find out whether the colour intensity is more or less than the Reference tube and record it in Table 7.1 given in section 7.6.

10. Similarly, compare the intensity of red colour in the remaining test tubes numbered 2,4 and 5 and record the observations in Table 7.1.

11. Similarly, we can study the effect of [Fe^{3+}] on the equilibrium by performing another experiment where we vary the concentration of Fe^{+++} while keeping the concentration of [CNS^-] constant. For this, use KCNS solution in step 2 and $Fe(NO_3)_3$ solution in steps 3 to 8. Record your observations in Table 7.2 given in section 7.6.

7.5 PRECAUTIONS

(1) All glass apparatus (test tubes and measuring cylinders) should be thoroughly clean, otherwise the solutions will stick to their sides and not mix properly.

(2) Volumes of solutions and distilled water should be measured carefully so that the solution of desired concentration can be obtained.

(3) Mixing of solution and water or of two solutions should be done by gentle shaking and avoiding their splashing.

7.6 OBSERVATIONS

Table 7.1 : Effect of concentration of CNS^- ion on the equilibrium

Test tube No.	Conc. of $Fe(NO_3)_3$ soln. used (mol l^{-1})	Conc. of KCNS soln. used (mol l^{-1})	Intensity of red colour as compared to the reference tube (more/less)	Shift in equilibrium (forward/ backward)
1	0.005	0.02	....	....
2	0.005	0.01	....	....
3	0.005	0.005	Reference	....
4	0.005	0.0025	....	....
5	0.005	0.00125	....	....

Table 7.2 : Effect of concentration of Fe^{3+} ions on the equilibrium

Test tube No.	Concn. of $Fe(NO_3)_3$ soln. used (mol l^{-1})	Conc. of KCNS soln. used (mol l^{-1})	Intensity of red colour as compared to the reference tube (more/less)	Shift in equilibrium (forward backward)
1	0.02	0.005	....	....
2	0.01	0.005	....	....
3	0.005	0.005	Reference	....
4	0.0025	0.005	....	....
5	0.00125	0.005	....	....

7.7 CONCLUSIONS

1. When any reactant concentration is increased, the equilibrium shifts in ____________ direction.
2. When any reactant concentration is decreased, the equilibrium shifts in ____________ direction.

7.8 CHECK YOUR UNDERSTANDING

1. *State Le Chatelier's Principle.*

   ....

2. *Why is the equilibrium reached by a reversible reaction called dynamic equilibrium?*

   ....

3. *What will happen to the equilibrium reached by mixing $Fe(NO_3)_3$ and KCNS solutions, if a few drops of $FeCl_3$ solution are added to it.*

   ....

4. *What will happen if some $[Fe(SCN)]^{2+}$ ions are removed from the above equilibrium ?*

   ....

5. *What will be the effect of addition of a few drops of dilute NH_4OH solution to the above equilibrium? Give reasons.*

   ....

7.9 NOTE FOR THE TEACHER

1. The teacher should help the students while doing the experiments.
2. Chemicals should be supplied in pure state.

7.10 CHECK YOUR ANSWERS

Ans.1. Le Chatelier's Principle states, when any system at equilibrium is disturbed by changing concentrations, temperature or pressure, the equilibrium shifts in a direction so as to nullify or reduce the effect of that change.

Ans.2. It is because even after equilibrium is established, two opposite reactions continue to occur but at the same rate.

Ans.3. The equilibrium will shift in forward direction as the concentration of reactant Fe^{3+} ion will increase on addition of $FeCl_3$.

Ans.4. As $[Fe(SCN)]^{2+}$ ions (product) are removed the equilibrium will shift in forward direction.

Ans.5. The equilibrium will shift in backward direction. It is because OH^- ions from NH_4OH will combine with some Fe^{3+} ions and form brown precipitate of $Fe(OH)_3$. Thus reactant (Fe^{3+} ions) concentration will decrease and the equilibrium will shift in backward direction.