Name: **Honors Chemistry**

Section: Lab: LeChatelier's Principle

Prelab

Turn in this page on the assigned date.

1. What is a spectator ion?

2. What will you observe if both ions added are spectator ions?

3. Only eleven solutions are tested. What is the purpose of the twelfth well on the microplate?

4. What macroscopic change indicates an increase in concentration of $FeSCN^{2+}$?

5. How do spectator ions affect the equilibrium concentrations?

6. Give the symbols for the ions present in a solution of sodium sulfate.

7. In your own words, describe the purpose of this experiment.

8. On a separate sheet of paper, construct a data table to record the following information: the name and formula of each reagent, the ions contained in each reagent, the well number (such as A-1 or D-5) of each reagent, and the color change (lighter, darker, or no change).

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If you've ever watched a game of football, you know that it has become very specialized. Coaches design special offenses and defenses for various down and position situations, as well as for positions of the ball on the field, the score, and the time remaining in the game. For example, offensive and defensive strategies are often quite different for a third down and one situation than for a first down and ten. As a result, several offensive and defensive players often run on and off the field after each play. One thing remains constant: there are only eleven players per team on the field for any given play. This is an example of a dynamic equilibrium. A dynamic equilibrium is one in which the forward reactions (players running on the field) take place at the same rate as reverse reactions (players running off the field). There is no net change in the number of players on the field.

Chemical systems often reach a state of dynamic equilibrium. In a system at chemical equilibrium, the rate of the forward reaction equals the rate of the reverse reaction. By adding or taking away reactants and/or products, we can change the balance of reactants and products. The position of the equilibrium is governed by *LeChatelier's principle*. LeChatelier's principle states that if a system at equilibrium is stressed,the equilibrium balance will shift in a direction that will relieve the stress. For example if we add a reactant, the equilibrium will shift toward products (to the right) so that there is a different balance of reactants and products. Similarly, if wd add products, it will shift toward reactants (to the left).

In this experiment, aqueous solutions of iron (III) chloride and potassium thiocyanate will be mixed. Iron (III) ions, Fe^{3+}, react with colorless SCN^- ions to for the brick-red complex ion, $FeSCN^{2+}$. The equation is as follows:

$$Fe^{3+}(aq) + 3\ Cl^-(aq) + K^+(aq) + SCN^-(aq) \leftrightarrow FeSCN^{2+}(aq) + K^+(aq) + 3Cl^-(aq)$$

The potassium and chloride ions are unchanged in the process. Because these ions do not participate in the reaction, they are called "spectator ions." The net equilibrium equation is as follows:

$Fe^{3+}(aq)$	+	$SCN^-(aq)$	$\leftrightarrow$	$FeSCN^{2+}(aq)$
Colorless		colorless		brick-red

At equilibrium, the color of the $FeSCN^{2+}$ ion is constant because the rate of formation of $FeSCN^{2+}$ is equal to the rate of its decomposition. You will disturb the equilibrium by adding pairs of ions to this system and observe any changes in color. At least one of the ions added in each pair is a spectator ion. If both added ions are spectator ions, there is no change in the equilibrium concentrations and therefore no change in color. If the color becomes darker, the shift in equilibrium must have caused an increase in the concentration of $FeSCN^{2+}$. If the color becomes lighter, the concentration of $FeSCN^{2+}$ must have decreased while the concentrations of Fe^{3+} and SCN^- increased.

Hypothesis (To be completed before doing the experiment)

Predict which of the solutions listed in the materials section of this experiment will shift the equilibrium to the left, and which will shift the equilibrium to the right. (Make sure each of the 11 solutions tested is included in your hypothesis section.)

Objectives

- Analyze color changes and relate them to shifts in equilibrium.
- Infer molecular events, which account for the observed changes.
- Present and explain the observed changes using LeChatelier's principle.
- Formulate a model to account for shifts in equilibrium and predict the results of other changes.

Materials
96-well microplate
50 mL beaker
25 mL graduated cylinder
0.1 M iron (III) chloride
0.1 M potassium thiocyanate
0.1 M sodium thiocyanate
0.1 M sodium chloride
0.1 M iron (III) nitrate
0.1 M ammonium nitrate
0.1 M sodium carbonate
0.1 M potassium bromide
0.1 M ammonium thiocyanate
0.1 M sodium hydroxide
0.1 M calcium iodide
Distilled water

Procedure
1. Put on your laboratory apron and safety goggles.
2. To the 50 mL beaker, add 3 drops of iron (III) chloride and 3 drops of potassium thiocyanate. Record your observations in your data table.
3. Add enough distilled water to the beaker so that the red color is less intense. Color changes due to shifts in equilibrium will be more noticeable in the more dilute solution.
4. Using a micropipette, add a few drops of the diluted solution to each of 12 wells of the microplate. Be sure to leave two or three empty wells between each filled well.
5. Choose one of the wells near the center of the plate to be your control. Using a micropipette, add one drop of water to this well; you will compare all other color changes to this well.
6. Place a sheet of white paper under the microplate. This will help you see the color changes more easily.
7. Add one drop of the first solution listed on your data table and record the result as lighter, darker, or no change.
8. Repeat step 7 for each of the remaining solutions.
9. Dispose of the solutions as directed by your teacher.
10. Before leaving the laboratory, clean up all materials and wash your hands thoroughly.

Analyze and Apply Questions

1. Explain how you recognized the spectator ions.
2. Predict the color effect and the change in concentration when one drop of each of the following solutions is added. (Note: this is NOT your data table!)

Solution	Color Change	Concentration of $FeSCN^{2+}$
Potassium carbonate		
Calcium thiocyanate		
Sodium bromide		
Potassium hydroxide		
Potassium nitrate		
Iron (III) bromide		
Ammonium bromide		
Iron (III) iodide		
Calcium hydroxide		
Ammonium carbonate		

3. Use LeChatelier's principle to describe the submicroscopic changes (i.e., particle level changes) that take place when one drop of a solution of ammonium thiocyanate is added to the solution in equilibrium. (Be as detailed as possible.)
4. Imagine that a lethal amount of the equilibrium mixture was swallowed. If $FeSCN^{2+}$ is very poisonous but Fe^{3+} and SCN^- are only slightly toxic, which solutions used in your experiment can be used as antidotes?
5. Novelty devices for predicting rain contain cobalt(II) chloride and are based on the following equilibrium: $CoCl_2(s) + 6\ H_2O \leftrightarrow CoCl_2{\bullet}6H_2O(s)$
   Purple pink
   What color will such an indicator be if rain is immiment?

For your conclusion, develop your own analogy of dynamic equilibrium. Show how this analogy relates to reversible reactions and the equilibrium state. Use changes in your analogy to illustrate LeChatelier's principle.

Also, compare your hypothesis statement to your experimental results. Were your results what you expected?