INVESTIGATING EQUILIBRIUM EXPERIMENT

Objectives

1. To observe the formation of an equilibrium system.
2. To recognize the macroscopic properties of two chemical systems at equilibrium.
3. To observe shifts in equilibrium concentrations as stresses are applied to the systems.
4. To explain observations by applying *LeChatelier's Principle*.

Materials

6 test tubes	test tube rack	2 -100mL beakers	beaker tongs
safety glasses	2-100 mL grad.cyl.	hot plate	scoopula
2 -250mL beakers		10mL grad cylinder	glass tubes

0.2M $FeCl_3$	0.2M KSCN	0.2M KCl	0.2M $Fe(NO_3)_3$
6.0M NaOH	$CoCl_2 \bullet 6H_2O$	6.0M HCl	water

Procedure

PART I

"Let's Play Equilibrium"

1. Label a 100 mL graduated cylinder 'A' and fill it to the 50 mL mark with water. Get a second 100 mL graduated cylinder and label it 'B' but leave it empty. Get two glass tubes of different diameters. Let the wider tube be in cylinder 'A'.
2. Two students (A and B) will simultaneously lower a glass tube into their respective cylinders without blocking the open ends of the tubes. When the tube reaches the bottom of the cylinder each will place the index finger over the top end of the glass tube. Then, transfer the water trapped in the tube to the opposite graduated cylinder and allow to drain. **Note:** Always return a given tube to the same graduated cylinder for refilling.
3. Record the volume in each cylinder starting at zero transfers and then at every fifth transfer up to a maximum of 100 transfers.
4. Continue transferring until you think that equilibrium has been attained.
5. Once equilibrium is reached, add 20 mL of water (a stress) to cylinder A and record the volumes again. Continue transferring and recording until a new equilibrium is reached.

PART II

1. Use a 10mL graduated cylinder to measure 1mL of 0.2M $FeCl_3$ and pour it into a 250mL beaker. Using another 10mL graduated cylinder, measure 1mL of 0.2M KSCN. Record the colour of each solution under the equilibrium reaction in <u>Data and Observations</u>.
2. Add the 1mL portion of 0.2M KSCN to the beaker containing 0.2M $FeCl_3$. Swirl the mixture and record the colour of $FeSCN^{2+}$ under the equilibrium reaction in <u>Data and Observations</u>. Add enough water to the solution (approx. 150 mL) to dilute the intense colour to a light amber colour.
3. Pour approximately 5mL of this solution into each of 5 test tubes labeled A to E. Test tube A serves as a control.
4. For each of the following reactions (steps 5-8), record the results in Table 1.
5. To test tube B, add 10 drops of 0.2M KCl.
6. To test tube C, add 10 drops of 0.2M $Fe(NO_3)_3$.
7. To test tube D, add 10 drops of 0.2M KSCN.
8. To test tube E, add 10 drops of 6.0M NaOH. *Pay careful attention to the consistency of the fluid upon adding the NaOH.
9. All solutions can go down the sink with plenty of water.

PART III

1. Place a pea-sized sample of $CoCl_2 \bullet 6H_2O$ into each of two 100mL beakers.
2. To the first beaker, add 10mL of 6.0M HCl and label the beaker #1 using a 10mL graduated cylinder.
3. To the second beaker, add 10mL of water. Record the colours in each beaker under the equilibrium reaction in <u>Data and Observations</u>.
4. Gradually add water to the solution in beaker #1 until a definite colour change occurs. Record observations in Table 2.
5. Place beaker #1 on a hotplate and heat gently. When a definite colour change is observed, shut off the burner. Using tongs, remove the beaker from the hotplate. Record the resulting colour in Table 2.
6. Add approximately 150mL of cold tap water to a clean 250mL beaker. Carefully place the warm beaker and contents from Step 5 upright into this cold water bath. Record any additional changes in color in Table 2.
7. All solutions can go down the sink with plenty of water.

Data and Observations

PART I

Design a table in order to display the data recorded. Graph the data (volume of water (y-axis) vs. # of transfers (x-axis)). Join each point with a smooth curve.

PART II

$$Fe^{3+}_{(aq)} \quad + \quad SCN^{-}_{(aq)} \Leftrightarrow \quad FeSCN^{2+}_{(aq)}$$

colour: __________ __________ ________________

Table 1 – Stresses in the iron (III) thiocyanate ion equilibrium

Reagent Added	Stress (ion change that causes shift)	Observation (colour change)	Direction of Equilibrium Shift
KCl (test tube B)			
$Fe(NO_3)_3$ (C)			
KSCN (D)			
NaOH (E)			

PART III

$$Co(H_2O)_6{}^{2+}{}_{(aq)} \quad + \quad 2Cl^{-}_{(aq)} \quad \Leftrightarrow \quad Co(H_2O)_4Cl_{2(aq)} \quad + \quad 2H_2O_{(l)}$$

colour: ________________ (Hint: 'Water' side) __________________(Hint: 'Acid' side)

Table 2 – Equilibrium Involving Cobalt (II) Complexes

	Stress	Observation (colour change)	Direction of Equilibrium Shift
Step 4			
Step 5			
Step 6			

Questions

PART I

1. Looking at the graph, how can it be perceived that equilibrium has been attained?
2. Aside from the 20 mL stress addition, where on the graph does the volume change the most quickly?

3. Look at Part I **after** the stress; how is the new equilibrium different from the original?
4. Equilibrium was reached twice. Calculate the ratio of Volume B to Volume A for each case. These are equilibrium constants for the system. How do they compare to each other with respect to size? Explain your findings.
5. Name two factors that affect the rate of water transfer excluding speed of transferals.

PART II

6. Apply *LeChatelier's Principle* to explain the results obtained when 0.2M $Fe(NO_3)_3$ was introduced into the iron (III) thiocyanate ion equilibrium system.

7a. What precipitate was formed when 6.0M NaOH was introduced into the iron (III) thiocyanate equilibrium system?

7b. Apply *LeChatelier's Principle* to explain the results obtained when 6.0M NaOH was introduced into the iron (III) thiocyanate ion equilibrium system.

PART III

8. For the cobalt (II) complex equilibrium, is the forward or reverse reaction endothermic? Support you answer with observations.

9. Rewrite the cobalt (II) complex equilibrium with "energy" on the appropriate side.

10. Predict how the addition of NaCl would affect the cobalt (II) complex equilibrium. Explain in terms of *LeChatelier's Principle*.

Conclusion

1. State the effect on the position of an equilibrium due to a change in concentration of a reactant or product.

2. State the effect on the position of an equilibrium due to a change in temperature.

**This experiment is based on Experiment 19A in* <u>*Heath Laboratory Experiments*</u>.