

Experiment #3: Shifting Reactions (Adapted from Exp. I-4 from *Inquiries in Chemistry*, 3<sup>rd</sup> edition)

Problem Statement: How can we shift reactions forward and backward?

I. Data Collections and Analysis

- A. Put about 50 mL of KSCN (potassium thiocyanate solution labeled 0.0005 M) in to a 100 mL beaker. Describe the appearance of the solution and the list the species (ions) in the solution. For each of the species in the solution describe its color.

Observations and important species:

- B. Look at the  $\text{Fe}(\text{NO}_3)_3$  (iron (III) nitrate solution labeled 0.2 M). Describe the appearance of this solution and list the species (ions) in the solution. For each of the species in the solution describe its color.

Observations and important species:

- C. Add about 5 drops of the  $\text{Fe}(\text{NO}_3)_3$  solution to the beaker containing the KSCN solution. Describe what you observe happens when the solutions are mixed. What evidence is there for a chemical reaction between  $\text{Fe}(\text{NO}_3)_3$  and KSCN.

Observations and evidence for a chemical reaction:

- D. Write the ionic and the net ionic equation for the reaction you observe. In the net ionic equation indicate the color of each species. Explain your answers to this part to your TA before you proceed.

Ionic equation:

Net ionic equation (and color):

- E. Fill each of three large test tubes about 1/3 full with the combined solution made in part C. Keeping one test tube as a standard for comparison, put a few crystals of KSCN into the second test tube and one drop of  $\text{Fe}(\text{NO}_3)_3$  solution into the third test tube. Record your observations below.

Test Tube 1	Test Tube 2 (add KSCN)	Test Tube 3 (add $\text{Fe}(\text{NO}_3)_3$ )

- F. Write the net ionic equation from D in the box below,

Describe what was interesting about the above reaction (as it occurred in part C) and your observations from part E? Explain this to your TA.

- G. Keep your standard (Test Tube 1), but discard the contents of the other two test tubes into your waste beaker. Rinse these test tubes and then refill each about 1/3 full with the combined solution from part C. Place one test tube in a hot water bath (50 - 70 °C) and the other in an ice bath. Leave each test tube in its bath about 10 minutes to ensure that the contents have reached the bath temperature. Remove the tubes and compare their color intensity to that of your standard. Record your observations.

Test Tube 1	Test Tube 2 (hot water bath)	Test Tube 3 (cold water bath)

Offer an explanation, at the ion level, using the net ionic equation, for why the color intensity varies as it does with temperature.

- H. Allow your test solutions to get back to room temperature. To the contents of test tube 2 add a small amount of solid sodium fluoride, NaF. The amount should be about the volume of a pencil eraser or less. Mix gently and note your observations below:

Observations:

- I. Place a few mLs of the solution from test tube 2 (in Part G) into each of two new, clean test tubes. Add a few mLs of KSCN solution to one and 3 - 6 drops of  $\text{Fe}(\text{NO}_3)_3$  solution to the other. Record your observations below:

Test Tube 4 (added KSCN)	Test Tube 5 (added $\text{Fe}(\text{NO}_3)_3$ )

- J. Fluoride ion,  $\text{F}^-$ , reacts with  $\text{Fe}^{3+}$  to form a complex ion  $\text{FeF}_6^{3-}$ . Knowing this, offer explanations for all the data you collected in H and I above.

Explanations:

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- K. Draw a molecular-level picture illustrating one of the effects: Part E Test Tube 2; Part E Test Tube 3; or Part H. (Your TA will assign one of these to you).

TA Assigned effect \_\_\_\_\_:

## Part II: Data Collection and Analysis:

- A. Put about 2 mL of  $\text{CuSO}_4$  (copper (II) sulfate solution labeled 0.1 M) in a test tube. Note the appearance of the solution and identify the species (ions) in the solution.

Observations and important species:

- B. Using a medicine dropper add  $\text{NH}_3$  (ammonia solution labeled 1 M) to the  $\text{CuSO}_4$  dropwise, mixing the solution between drops. Make observations and continue adding the  $\text{NH}_3$  by the dropperful until the total volume is approximately 6 mL. Record your observation below.

The reactions you observed are:  $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$   
 $\text{Cu}^{2+}(\text{aq}) + 4\text{NH}_3(\text{aq}) \rightarrow \text{Cu}(\text{NH}_3)_4^{2+}(\text{aq})$

Identify the colors of each reactant and product of the above reactions.

$\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$        $\text{Cu}^{2+}(\text{aq}) + 4\text{NH}_3(\text{aq}) \rightarrow \text{Cu}(\text{NH}_3)_4^{2+}(\text{aq})$   
Color

- C. Add HCl (hydrochloric acid labeled 1.5 M) dropwise to the solution in part B. Make observations and continue adding HCl until 3 mL have been added.

$\text{NH}_3(\text{aq})$  solution is basic: It contains  $\text{OH}^-$  ion. Also,  $\text{H}^+$  from  $\text{HCl}$  will react with  $\text{NH}_3$  to form  $\text{NH}_4^+$ . Knowing this, offer an explanation for your observations.

- D. Add the  $\text{NH}_3(\text{aq})$  dropwise to the solution in part C. Make observations and continue adding the  $\text{NH}_3$  until the total volume is approximately 15 mL. Record your observation below.

Offer an explanation for these data.

### III: Conclusions

Given all that you have seen in these experiments, what are your answers to the Problem Statement at the beginning of the experiment. Justify your answers by citing data.

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