LeChatelier's Principle: Iron(III) Thiocyanate Equilibria

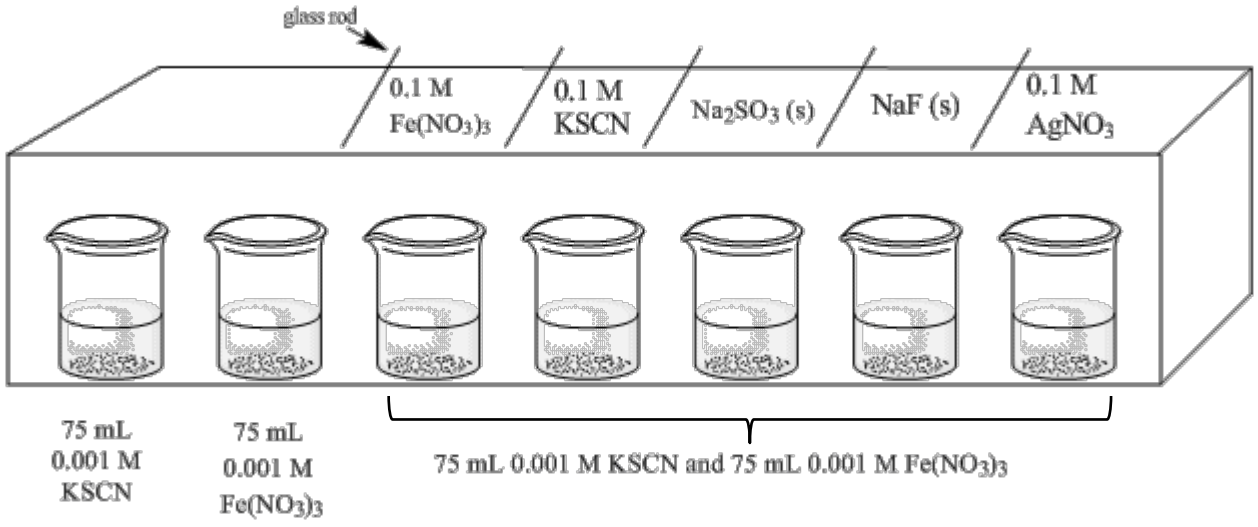
Looks like Tang, tastes like going to the hospital to get your stomach pumped

Chemicals and Equipment Needed

- LeChatelier's Principle Kit – **O2**
  - Dropper bottle of 0.10 M $Fe(NO_3)_3$
  - Dropper bottle of 0.10 M KSCN
  - Dropper bottle of 0.10 M $AgNO_3$
  - Small vial of NaF (s)
  - Small vial of Na_2SO_3 (s)
- ~500 mL 0.001 M $Fe(NO_3)_3$ – **H4**
  - If low, can be made from stock solution (0.1 M, also **H4**)
- ~500 mL 0.001 M KSCN – **H4**
  - If low, can be made from stock solution (0.1 M, also **H4**)
- 7-300 mL tall beakers – **Q2**
- 6 stirring rods – **U1**
- 2 microspatulas – **U1**
- Light box – **A4**

Preparation

- **MAKE SURE TO USE THE CORRECT CONCENTRATIONS!**
- Set up 7 beakers in a row.
- Add 75 mL 0.001 M $Fe(NO_3)_3$ to the 1st beaker (colorless), cover with labeled petri dish
  - Just use the marking on the beakers, no need to use graduated cylinders
- Add 75 mL 0.001 M KSCN to the 2nd beaker (colorless), cover with labeled petri dish
- Add 75 mL 0.001 M $Fe(NO_3)_3$ AND 75 mL 0.001 M KSCN to the last five beakers, producing the orange colored species $FeSCN^{2+}$. Cover with petri dishes labeled **$FeSCN^{2+}$.**
  - The solution should look like Tang or Kool-Aid. If it is dark or brown, you used the wrong concentration
- Set the dropper bottles, vials of reagents, stirring rods, and microspatulas on top of the light box according to the diagram below:



Presentation

Before each beaker, ask the audience to predict how equilibrium will shift

Beaker 1- reference color

- Add the 75 mL 0.001 M KSCN to the beaker containing only 0.001 M $Fe(NO_3)_3$ to show formation of the colored $FeSCN^{2+}$ complex ion from two colorless solutions.

  SCN^- (aq) + Fe^{3+} (aq) → $FeSCN^{2+}$ (aq)

  colorless orange

Beaker 2- Add a squirt or two of 0.10 M $Fe(NO_3)_3$

- **Observation:** The color intensifies
- **Conclusion:** There must have been free SCN^- available to react with the added Fe^{3+}

Beaker 3- Add a squirt or two of 0.10 M KSCN

- **Observation:** The color intensifies
- **Conclusion:** There must have been free Fe^{3+} available to react with the added SCN^-

Beaker 4- Add a small amount of solid Na_2SO_3

- **Observation:** The color fades
- **Conclusion:** The equilibrium has shifted to the left, due to removal of Fe^{3+} by reduction with SO_3^{2-}

  2 Fe^{3+} (aq) + SO_3^{2-} (aq) + H_2O → 2 Fe^{2+} (aq) + SO_4^{2-} (aq) + 2 H^+ (aq)

Beaker 5- Add a small amount of solid NaF

- **Observation:** The color fades
- **Conclusion:** The equilibrium has shifted to the left, due to removal of Fe^{3+} by formation of a complex with F^-

  Fe^{3+} (aq) + n F^- (aq) → FeF_n^{3-n} (aq)

Beaker 6- Add a squirt or two of 0.10 M $AgNO_3$

- **Observation:** The color fades, and the solution turns cloudy
- **Conclusion:** The equilibrium has shifted to the left, due to removal of SCN^- by precipitation

  Ag^+ (aq) + SCN^- (aq) → AgSCN (s)

Clean-Up

- All the solutions can go down the sink except the one containing AgSCN (the cloudy one), which should go in the WWC

NOTES:

- To make the stock solutions:
  - 0.100 M $Fe(NO_3)_3$
    - 40.402g $Fe(NO_3)_3$•9 H_2O in 500 mL d-H_2O, add 63mL conc. HNO_3, dilute to 1L
  - 0.100 M KSCN
    - 9.718g KSCN in 500 mL d-H_2O, then dilute to 1L
- To make the 0.0010 M solutions:
  - Take 10 mL of the appropriate solution, dilute to 1L

LeChatelier's Principle: Instructor Notes

Beaker 1- reference color

- Add the 75 mL 0.001 M KSCN to the beaker containing only 0.001 M $Fe(NO_3)_3$ to show formation of the colored $FeSCN^{2+}$ complex ion from two colorless solutions.

  $KSCN\ (aq) + Fe(NO_3)_3\ (aq) \rightarrow FeSCN^{2+}\ (aq) + K^+\ (aq) + 3\ NO_3^-\ (aq)$

  $SCN^-\ (aq) + Fe^{3+}\ (aq) \rightarrow FeSCN^{2+}\ (aq)$ **orange complex**

Beaker 2- Add a squirt or two of 0.10 M $Fe(NO_3)_3$

- **Observation:** The color intensifies
- **Conclusion:** There must have been free SCN^- available to react with the added Fe^{3+}

Beaker 3- Add a squirt or two of 0.10 M KSCN

- **Observation:** The color intensifies
- **Conclusion:** There must have been free Fe^{3+} available to react with the added SCN^-

Beaker 4- Add a small amount of solid Na_2SO_3

- **Observation:** The color fades
- **Conclusion:** The equilibrium has shifted to the left, due to removal of Fe^{3+} by reduction with SO_3^{2-}

  $2\ Fe^{3+}\ (aq) + SO_3^{2-}\ (aq) + H_2O \rightarrow 2\ Fe^{2+}\ (aq) + SO_4^{2-}\ (aq) + 2\ H^+\ (aq)$

Beaker 5- Add a small amount of solid NaF

- **Observation:** The color fades
- **Conclusion:** The equilibrium has shifted to the left, due to removal of Fe^{3+} by formation of a complex with F^-

  $Fe^{3+}\ (aq) + n\ F^-\ (aq) \rightleftharpoons FeF_n^{3-n}\ (aq)$

Beaker 6- Add a squirt or two of 0.10 M $AgNO_3$

- **Observation:** The color fades, and the solution turns cloudy
- **Conclusion:** The equilibrium has shifted to the left, due to removal of SCN^- by precipitation

  $Ag^+\ (aq) + SCN^-\ (aq) \rightarrow AgSCN\ (s)$