Reversible and Irreversible Processes (Modified from an SWH laboratory by Thomas Greenbowe and Kathy Burke)

Introduction (No Change)
Safety

Objective
In this laboratory you will investigate four (five so one can be an irreversible reaction) chemical systems.

Concepts (Prior Knowledge)
During your first semester of chemistry you investigated several types of chemical reactions including; precipitation reactions, neutralization reactions, synthesis/formation reactions, and combustion reactions. While these reactions are all very different from each other in many respects, in one respect they are similar. These reactions were used during the discussion of stoichiometry, limiting reagents and excess reagents. Consider the reaction of glucose with oxygen,

$$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$$

This is an example of a combustion reaction that occurs in the body to produce energy, glucose reacting with oxygen to produce carbon dioxide and water. We can talk about how for respiration oxygen is the excess reagent and glucose is the limiting reagent. For a particular amount of glucose we can calculate the amounts of carbon dioxide and water that would be produced in the presence of excess oxygen. These are the types of questions we can answer using stoichiometry.

What about the reverse reaction?

$$6CO_{2(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6(s)} + 6O_{2(g)}$$

Would you expect a mixture of carbon dioxide gas and water liquid in a container in the laboratory to produce glucose and oxygen?

This is an example of a chemical reaction that proceeds in only one direction. Are all reactions like this?

Procedure
Part 1:

Work in pairs to perform this activity. As a class, decide how you want to divide the work to conduct your analyses and share your results.

Materials Available

| | |
|---|---|
| 13 x 100 mm test tubes | 0.10 M $Mg(NO_3)_2$ |
| Plastic dropper pipets | 0.10 M $Na_2CO_3$ |
| Small test tubes | |
| Test tube holder | |
| Distilled Water | |
| Centrifuge | |

Obtain a solution of magnesium nitrate and a solution of sodium carbonate. Describe each solution. Transfer 40 drops of the magnesium nitrate solution to a small test tube. Add 10 drops of sodium carbonate to the solution of magnesium nitrate. (Note: you may prefer to try a different combination of drops of each reagent. If you elect to do that be sure to record the number of drops of each reactant.) Describe what you observe happening.

Write a chemical equation (write the molecular, ionic and net ionic equations) to represent the reaction that occurred when magnesium nitrate and sodium carbonate were mixed.

For your combination of drops of each reactant, predict which compound is the limiting reagent and which compound is the compound in excess. Explain the basis of your prediction.

Describe experiments that could be done to produce evidence to support your claim (prediction above) of which compound is the LR and which is in excess.

Perform the experiment(s), describe your observations and explain how accurate your prediction turned out.

For this reaction place a sample of the solid product in a sample test tube, and add 20 – 40 drops of distilled water. Do you expect the solid to dissolve? Explain. What experiment(s) could you do to provide evidence to support or refute your prediction?

Procedure
Part 2:

Work in pairs to perform this activity. As a class, decide how you want to divide the work to conduct your analyses and share your results.

Materials Available

| | |
|---|---|
| Small test tubes | 0.050 M $Fe(NO_3)_3$ |
| Plastic dropper pipets | 0.050 M KSCN |
| Distilled Water | solid NaF |
| Test tube holder | |
| Beaker for water baths | |
| Hot Plate for hot water bath | |
| Ice for cold water bath | |

Mix 4 drops of 0.050 *M* $Fe(NO_3)_3$ with 4 drops of 0.050 *M* KSCN in 5 to 10 mLs of distilled water. Describe what you observe. Can you detect any changes in temperature of the test tube and its contents. Record your observations.

The product of mixing $Fe(NO_3)_3$ and KSCN is the complex ion $Fe(SCN)^{2+}$. Write a net ionic equation that represents the reaction that occurs.

Predict which compound is the limiting reagent and which compound is the compound in excess. Separate the original 10 mLs of solution into three identical test tubes. Place the test tubes in a test tube rack.

Describe experiments that could be done to produce evidence to support your claim of which compound is the LR and which is in excess. (We will use 0.05 *M* solutions for the tests.)

Perform the experiments and describe your observations and how accurate your prediction turned out. (NOTE: In your experiment separate the original solution equally into two petri dishes.)

Explain what you observed using the chemical reaction you had written earlier.

Obtain a small amount of NaF. Add some NaF to a test tube containing 10 drops of 0.050 M $Fe(NO_3)_3$. Describe what you observe happening.

Obtain a small amount of NaF. Add some NaF to a test tube containing 10 drops of 0.050 M KSCN. Describe what you observe happening.

Obtain a small amount of NaF. Add some NaF to the third test tube containing the mixture of $Fe(NO_3)_3$ and KSCN. Predict what might happen?

Describe what you observe happening.

Explain what you observed using the chemical reaction you had written earlier.

How does the original system respond to being heated or cooled in a water bath?

Part 3:
Work in pairs to perform this activity. As a class, decide how you want to divide the work to conduct your analyses and share your results.

Materials Available

Small test tubes
Plastic dropper pipets
Distilled Water
Test tube holder
Beaker for water baths
Hot Plate for hot water bath
Ice for cold water bath
6.0 M HCl
solid $CoCl_2$
95% ethanol
0.10 M $CoCl_2$ (in distilled water)

Begin by adding solid $CoCl_2$ to approximately 20 mLs of 95% ethanol. Describe what you observed.

Pour equal amount of the solution into three other test tubes. Add 2 drops of water to one of the test tubes, add 4 drops of water to another test tube.

How does the mixture of $CoCl_2$ with respond to being heated or cooled in a water bath?

Analysis:

Summarizing the findings using the four parts of this activity.

1a) Explain the difference between a reversible and an irreversible reaction.

1b) In a reversible reaction, adding a reactant shifts the reaction to which side?

1c) In a reversible reaction, adding a product shifts the reaction to which side?

1d) In a reversible reaction, removing a reactant shifts the reaction to which side?

1e) In a reversible reaction, removing a product shifts the reaction to which side?

1f) In a reversible reaction, how does adding or removing heat shift the reaction?

2. For each reagent you added in Parts 1 – 3 write a chemical equation to identify the chemical reaction that is occurring.

3. Write a general statement to summarize what you have learned about these reaction systems.