Equilibrium Systems
Experiment 7

PURPOSE

In this experiment, you will look at different equilibria, observe how addition or removal of components affects those equilibria and see if the results are consistent with Le Chatelier's principle.

PRINCIPLES

Any chemical reaction tends to proceed until the rate of the forward reaction becomes equal to the rate of the reverse reaction. The reaction then is said to be at equilibrium. Adding or removing a component, in an equilibrium system, will disturb the dynamic balance between two rates by forcing the forward and reverse reaction rates to become unequal. In order for the chemical system to reestablish equilibrium the concentration of all components must change. One way of predicting these concentration shifts is through the use of Le Chatelier's principle: When a stress is applied to a system at equilibrium, the system will shift in the direction that reduces the stress and a new equilibrium is established.

In this experiment, you will look at different equilibria, observe how addition or removal of components affects those equilibria and see if the results are consistent with Le Chatelier's principle.

I. Saturated Solution Equilibria

Suppose we have a solution that has been saturated with a solute: This means that the solution has already dissolved as much solute as possible. If we try to dissolve additional solute, no more will dissolve, because the saturated solution is in equilibrium with the solute:

$$\text{Solute + Solvent} \rightleftharpoons \text{Solution}$$

Le Chatelier's principle is most easily seen when an ionic solute is used: Suppose we have a saturated solution of sodium chloride, NaCl. Then

$$NaCl_{(s)} \rightleftharpoons Na^{+}_{(aq)} + Cl^{-}_{(aq)}$$

will describe the equilibrium that exists. The rate ions leave the solid and go into the solution is just equal to the rate ions from the solution combine and precipitate. If $Na^{+}(aq)$ or $Cl^{-}(aq)$ is added to a solution saturated in $NaCl_{(s)}$, the rate at which ions combine to form a solid becomes greater than the rate at which ions dissolve. The net result is that $NaCl_{(s)}$ precipitates until the rates are again equal.

II. Acid/Base Equilibria

Many acids and bases exist in solution in equilibrium with their ions: This is particularly true for weak acids and bases. As an example, the weak base ammonia is involved in an equilibrium in aqueous solution

$$NH_3(aq) + H^+ (aq) \rightleftharpoons NH_4^+(aq)$$

Once again, we will use Le Chatelier's principle to play around with this equilibrium. We will try adding more ammonium ion or hydrogen ion to see what happens. Since none of the components of this system is itself colored, we will be adding an acid/base indicator that changes color with hydrogen ion concentration or pH. The change in color will provide us with valuable information related to the position of the ammonia equilibrium.

PROCEDURE

I. Solubility Equilibria and Common Ion Effects

1. Obtain 5 mL of **saturated sodium chloride solution** in a test tube. This solution was prepared by adding solid NaCl to water until no more would dissolve. Then the clear solution was filtered from any undissolved solid NaCl.

   Add 10-20 drops of concentrated HCL to the 5 mL solution of saturated NaCl solution. *Note: Concentrated (12M) HCl is 12 M in Cl^- and 12 M in H^+)*

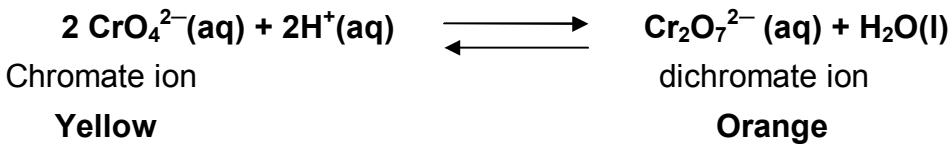
Tube	1
sat $NaCl_{(aq)}$	5 mL
Addition of HCl 12 M	10 -20 drops

   Examine the test tube carefully. In your notebook and on the report form, describe what happens in terms of Le Chatelier's principle.

2. Obtain 2 mL of **1.0 M K_2Cr0_4 solution** in a test tube. Add 2 mL of distilled water and mix vigorously. Now add 6.0 M HCl drop wise (about one mL) and stir. Record your observations.

K_2Cr0_4 1.0 M solution	Distilled Water	HCL 6.0 M solution
2 mL	2 mL	1 mL

The reaction you are observing is the formation of the dichromate anion according to the following equilibrium:



Now add about 1 mL of 6.0 M NaOH to the test tube containing the orange solution. Record and explain your observations in terms of Le Chatelier's principle.

K_2Cr0_4 1.0 M solution	Distilled Water	HCL 6.0 M solution	NaOH 6.0 M NaoH
2 mL	2 mL	1 mL	1 mL

II. Acid/Base Equilibria

Under the fume hood, prepare a dilute ammonia solution by adding 4 drops of concentrated ammonia to 100 mL of water.

Add 3 drops of phenolpthalein to the dilute ammonia solution, which will turn pink.
Place about 5 mL each of the pink dilute ammonia solution into two test tubes.
To one of the test tubes, add several small crystals of ammonium chloride.
To the other test tube, add a few drops of 12M HCl.

Tube	1	2
Stock Solution	5 mL	5 mL
Addition	A few Small crystals of NH_4Cl	A few drops of HCl 12 M

Describe what happens to the pink color in terms of how Le Chatelier's principle is affecting the equilibrium system.

Name:_____
Partner: _____

EQUILIBRIUM SYSTEMS
REPORT FORM

I. Solubility Equilibria and Common Ion Effects

1. Observation when concentrated HCl is added to a saturated solution of NaCl.

_____

_____

Indicate the stress applied, the shift in equilibrium and the concentration changes of all reagents in the new equilibrium:

Equation: ☐ ⇌ ☐ + ☐

Stress: …….. ☐

Shift:……... ☐

New Equilibrium: ☐ ⇌ ☐ + ☐
(Increased or …… ……... ……
decreased)

Account for your observation(s) by explaining it/them in terms of Le Chatelier's principle:

_____

_____

_____

_____

2. Observation when HCl is added to the K_2CrO_4 solution

_____

_____

Write out pertinent equilibrium that illustrates what happens when HCl is added to the K_2CrO_4 solution.
Indicate the stress applied, the shift in equilibrium and the concentration changes of all reagents in the new equilibrium:

Equation: ☐ + ☐ ⇌ ☐ + ☐

Yellow **Orange**

Stress: …… ☐

Shift:……..... ☐

New Equilibrium: (Increased or decreased ☐ ☐ ⇌ ☐ ☐

Account for what you have observed when HCl was added to the K_2CrO_4 solution, by providing an explanation in terms of Le Chatelier's principle :

_____

_____

_____

_____

_____

Observation when NaOH is added to K_2CrO_4/HCl solution

_____

_____

Write out pertinent equilibrium that illustrates what happens when NaOH is added to the acidic solution of K_2CrO_4.
Indicate the stress applied, the shift in equilibrium and the concentration changes of all reagents in the new equilibrium:

Equation: ☐ + ☐ ⇌ ☐ + ☐

Yellow **Orange**

Stress: …… ☐

Shift:……..... ☐

New Equilibrium: (Increased or decreased ☐ + ☐ ⇌ ☐ + ☐

Account for what you have observed when NaOH was added to the acidic solution of K_2CrO_4 solution, by providing an explanation in terms of Le Chatelier's principle:

_____

_____

_____

_____

_____

II. Acid Base Equilibria

Observation when a few crystals of NH_4Cl are added to the pink NH_3 solution containing phenolphtalein.

_____

Write out the pertinent equilibrium.

Indicate the stress applied, the shift in equilibrium and the concentration changes of all reagents in the new equilibrium:

Equation: ☐ + ☐ ⇌ ☐ + ☐

Stress:…… ☐

Shift:……..... ☐

New Equilibrium: (Increased or decreased ☐ + ☐ ☐ + ☐

Explain by completing the blanks:

The presence of the _____ ions make the aqueous solution of NH_3 turn pink when phenolphthalein is added. The addition of NH_4Cl, a soluble salt, _____ (increases, decreases) the concentration of the _____ ions in the equilibrium system.

This causes the equilibrium to shift to the _____ , which in turn decreases the concentration of the _____ ions. As a result the solution is no longer pink.

Observation when HCl is added to the pink NH_3 solution containing phenolphtalein.

_____

Write out the pertinent equilibrium.

Indicate the stress applied, the shift in equilibrium and the concentration changes of all reagents in the new equilibrium:

Equation: ☐ + ☐ ⇌ ☐ + ☐

Stress:……☐

Shift:…….....☐

New Equilibrium: (Increased or decreased ☐ + ☐ ☐ + ☐

Explain by completing the blanks:

The addition of _____ ions (from HCl) _____ (increases, decreases) the concentration of the OH^- ions, since they react forming water as illustrated by the Net ionic Equation below:

☐ ⟶

The _____ in the concentration of the OH^-, ions shifts the equilibrium to the _____ .

The concentration of OH^- ions formed in the new equilibrium is _____ (more, less) than that in the original equilibrium.