EXPERIMENT 3

Qualitative Aspects: Equilibrium & Le Chatelier's Principle

INTRODUCTION:
The purpose of this experiment is to study qualitative aspects of chemical systems in dynamic equilibrium. In doing this experiment, you will learn the operation of Le Chatelier's principle.

PROCEDURE:

(1) In an aqueous solution of iodine, the following equilibrium exists:

$$\mathbf{I_2\,(aq) + H_2O\,(l) \rightleftharpoons 2\,H^+\,(aq) + I^-\,(aq) + IO^-\,(aq)}$$

Pour about 1 mL of aqueous iodine solution in a clean test tube and observe the color. Any color in the solution can be regarded as entirely due to the presence of I_2 (aq).

Slowly add 1 to 2 drops of dilute 6 M sodium hydroxide solution to the solution of iodine and observe any color change. The OH- (aq) ions from the sodium hydroxide solution will react with the H+ (aq) ions present to form largely unionized water. Taking this into account, explain the observed color change. What should be added to swing the equilibrium in the opposite direction? Carry out a test to see if this is correct. Record your findings in your lab notebook.

(2) When iron (III) ions are mixed with thiocyanate ions, a blood red colored solution results from formation of a new ion as described in the following equation:

$$\mathbf{Fe^{3+}(aq) + SCN^-\,(aq) \rightleftharpoons FeSCN^{2+}(aq)}$$

In your lab notebook, predict what would be the effect on the intensity of the blood-red color of adding a more concentrated solution of:

(i) iron (III) chloride
(ii) potassium thiocyanate to separate portions of the equilibrium mixture?

Mix together equal volumes of 1 x 10^{-2} M solutions of iron (III) chloride and potassium thiocyanate. Now test your prediction by dividing an equilibrium mixture into two test tubes and observing separately the effects of adding drops of 1 M solutions of iron (III) chloride to one test tube and of potassium thiocyanate to the other.

(3) (A) Cobalt (II) salts form complex compounds readily. The pink aqueous solutions of cobalt (II) salts are characteristic of the complex ion $[Co(H_2O)_6]^{2+}$, in which the cobalt (II) ion is bonded to six water molecules in an octahedral arrangement. If Cl ions are present in sufficient concentration, they will compete effectively with the water molecules for bonding to the cobalt ion to form a deep blue solution of $CoCl_4^{2-}$. The resulting equilibrium may be written as follows:

$$\underset{\text{pink}}{\mathbf{[Co(H_2O)_6]^{2+} + 4\,Cl^-}} \rightleftharpoons \underset{\text{blue}}{\mathbf{CoC1_4^{2-} + 6\,H_2O}}$$

To 1.0 mL of a 0.4 M Co^{2+} solution, add two successive 0.5-mL increments of concentrated 12 M hydrochloric acid. What would be the expected effect of adding water to the resulting equilibrium mixture? Test your prediction by adding 5.0-mL increments of distilled water to the contents of your test tube.

(B) An Investigation of the Effect of Changing Temperature on a System at Equilibrium

(1) In a small Erlenmeyer flask, mix 10 mL 0.4 M Co^{2+} solution and 6 mL concentrated HCI to produce a violet solution (halfway between the original pink and bright blue). If necessary, adjust the color by adding distilled water or concentrated HCI a drop at a time.

(2) Divide the violet solution into three test tubes. Reserve one at room temperature for comparison; place the second in an ice bath; place the third in a beaker of boiling water.

(3) From the observed color changes determine how these temperature changes affect the balance of the equilibrium. Determine whether the color changes are reversible. Extending the equilibrium principle to cover such cases, we can observe that a temperature increase shifts the equilibrium balance in favor of the endothermically formed component, while a temperature decrease favors the formation of the exothermically formed component.

EXPERIMENT 3: **Qualitative Aspects: Equilibrium & Le Chatelier's Principle**

Report Sheet Name: _____

Qualitative Observations

(1) Iodine Test:

Color observations of aqueous iodine:_____

Color change observations: _____

Color change is due to the addition of _____ & color is due to the presence of _____

Explain chemically the observed color change.

What was added to swing the equilibrium in the opposite direction? _____

(2) Thiocyanate Test:

Color change observations:

What was the effect on the intensity of the blood-red color of adding a more concentrated solution of

(i) iron (III) chloride:

(ii) potassium thiocyanate to separate portions of the equilibrium mixture:

Did your results match your predictions?

(3) Cobalt (II) salts

(a) Color change observations:

To 5.0 mL of a 0.4 M Co^{2+} solution, you added two successive 2.0 mL increments of concentrated hydrochloric acid. What was the effect of adding water to the resulting equilibrium mixture?

(b) Color change observation under the three different conditions:

room temperature-

ice bath-

boiling water-

From the observed color changes, describe how these temperature changes affect the balance of the equilibrium.

Describe whether the color changes were reversible.

Based on your observations, was the reaction, as written on page 1, endothermic or exothermic?