Equilibrium: An Application of Le Chatelier’s Principle

(Adapted from AP Investigation 13: Can we make the colours of the rainbow?)

Introduction:

The central challenge is to investigate Le Chatelier’s Principle by testing several systems at equilibrium and then selecting specific ones to produce the colours of the rainbow based on specific applications of Le Chatelier’s Principle. An additional challenge involves selecting which reaction system to use for which colour in producing the rainbow while trying to only use a given “stress” once.

Learning Intentions:

Use Le Chatelier’s Principle to design a set of conditions that will optimize a desired outcome: producing the colours of the rainbow.

B3 – apply Le Chatelier’s Principle to the shifting of equilibrium.

Materials:

beakers test tube racks ice distilled water

graduated cylinders test tubes hot plates stirring rods

In addition to the above materials, you will have the following reagents available to you for each reaction.

Solutions containing **cobalt** or **copper** must be disposed of in the proper jar and may not be poured down the sink.

**Important: you may only combine materials within a given tray. You may not transfer the reagents to another tray.**

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Tray 1: HB  H+ + B-

Yellow Blue

Bromthymol blue indicator (HB)

0.10 M HCl

0.10 M NaOH

0.10 M NaCl

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Tray 2: Fe+3 + SCN-  FeSCN+2

 Yellow Red

0.10 M KSCN

0.20 M Fe(NO3)3

Solid KSCN

Solid FeCl3

Solid Na2HPO4, NaH2PO4, or Na3PO4

0.10 M KNO3

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Tray 3: Cu+2 + 4NH3  [Cu(NH3)4]+2

 Pale blue Deep blue

0.25 M CuSO4

Concentrated NH3

1. M HCl

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 Blue Green

Solid CuCl2

Concentrated HCl

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Tray 6: CO2(g) CO2(aq) + H2O(l) H2CO3(aq) HCO3-(aq) + H+

 Yellow Red

Club soda (contains CO2)

Methyl Red indicator (for yellow and red colours)

Syringes with locks (to change pressure)

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Procedure:

Possible equilibrium systems for your use are described in the materials section. You will need to investigate some or all of them and make predictions. Know that in some cases the applied stress may simply reinforce the current colour of the equilibrium system and produce no observable changes.

Be sure to use small quantities of reagents, add these reagents dropwise with stirring, and use hot plates or ice baths to heat or cool your samples should you wish.

Be sure to keep detailed records, including a step-by-step procedure, a list of materials used, all data and observations. You need to clearly indicate the reactant and product species in each system, the stressor you applied, and the resulting colour.

Once you have completed all your investigations and decided which reactions are stresses you will use to prepare your rainbow display, you may be asked to produce the display for your teacher.

Analysis:

1. For each equilibrium system studied, identify the reactants, products, and the result of each change of conditions. Clearly indicate the type of stress each change of conditions imposed, the colour produced, and the reasons for the change. **You need to clearly explain how the applied stress resulted in the observed colour.** Use Le Chatelier’s Principle in your explanations, but do not simply quote it as a substitute for a proper chemical explanation.
2. In an equilibrium system all the chemical species are present, but some are in greater concentration than others. In each system, list the chemical species responsible for the colour observed as well as the other species present in the mixture.