Indicator Lab

Introduction:

Using HA as a generalized acid, and B^- as a generalized base, the equation for a Bronsted-Lowry acid-base reaction is shown as follows:

$$HA + B^- \Longleftrightarrow A^- + HB$$

If the reaction equilibrium shown above favours the products over the reactants, then HA must be a stronger acid than HB (AND, B^- must be a stronger base than A^-). In other words, HA has a greater tendency to give off a proton than HB, and B^- has a greater tendency to accept a proton than A^-.

An acid-base indicator is a weak acid or base whose conjugate base or acid exists as a different colour. The pH at which the colour changes varies from one indicator to another, and the colour change takes place over a range of pH values. Thus, indicators can be used to determine an approximate pH (or $[H^+]$) of a solution.

In this experiment, you will use five different indicators which will be identified only by number. They will be added to two known solutions (1 M HCl; 1 M NaOH), and then to each of six unknown solutions containing a conjugate acid-base pair. Each of these six solutions will have a different pH. After recording and interpreting your results, you will be able to deduce the relative strengths of all eleven solutions (5 indicator solutions and 6 unknown solutions), and arrange them in order of decreasing strengths of acids (or increasing strengths of conjugate bases). For example, say you drop phenol red into a solution with an unknown pH and the colour is yellow. It can be deduced, therefore, that the pH of the unknown solution is < 6.6 and that it is a stronger acid than phenol red. Other results can then be used to increase the precision of the deductions.

Objectives:

1. To obtain an understanding of the equilibria that can exist between acids and bases.

2. To observe the colour changes that occur with a number of different acid-base indicators in several different solutions.

3. To arrange all the Bronsted-Lowry acids involved in this experiment in order of decreasing strength.

Materials:

Apparatus:
Spot Plates (2)
Lab Apron
Safety Goggles
Latex Gloves for solution handlers

Reagents:
1 M HCl
1 M NaOH
6 solutions of different pH
(labeled HA_1/A_1^-, etc…)
5 different indicator solutions
(labeled HIn_1/In_1^-, etc…)

Procedure:

1. Put on your lab apron and safety goggles.
2. Obtain two spot plates and have a group member keep track of what substance(s) are in what spots.
3. Place 4 drops of 1 M HCl into 5 spots.
4. Add one drop of each indicator solution to each spot containing the HCl and record the colour in your rough copy of Table 1 from the *Data and Observations* section. *These results will provide you with the colour of the acid form of each indicator.*
5. Repeat steps 3 and 4, using 1 M NaOH instead of HCl. *These results will provide you with the colour of the base form of each indicator.*
6. Repeat steps 3 and 4 with unknown solution HA_1/A_1^- and the five different indicators, and continue the process with all the other unknown solutions until you have recorded the colour in all 30 possible combinations of unknown solution with unknown indicator. *You will have to rinse and dry your spot plates once at some point(s) in order to continue.*
7. Wash your hands thoroughly with soap and water before leaving the lab.

Reagent Disposal:

Rinse ALL chemicals down the sink with plenty of water.

Post-Lab Discussion:

In order to interpret the results and deduce a list of acid strengths, consider the following examples:

Example 1: $HA_1 + In_3^- \Leftrightarrow A_1^- + HIn_3$

If in this combination the indicator (HIn_3) is showing the colour of its acid form, then HA_1 is a stronger acid than HIn_3, since HA_1 was able to donate a proton to In_3^-.

Example 2: $HA_3 + In_5^- \Leftrightarrow A_3^- + HIn_5$

If in this combination the indicator (HIn_5) is showing the colour of its base form, then HIn_5 is a stronger acid than HA_3, since HIn_5 was able to donate a proton to A_3^-.

Example 3: $HA_2 + In_1^- \Leftrightarrow A_2^- + HIn_1$

If in this combination the indicator (HIn_1) is showing its intermediate colour, you must do your best to deduce whether the intermediate colour is more acid-like or more base-like, and then rank accordingly as you did in the previous two examples. If the colour is, in your estimation, a *perfect* intermediate, then HA_2 and HIn_1 are EQUAL in strength.

Data and Observations:

Table 1 – Colours observed upon mixing different solutions with different indicators

	HIn_1/In_1^-	HIn_2/In_2^-	HIn_3/In_3^-	HIn_4/In_4^-	HIn_5/In_5^-
HCl					
NaOH					
HA_1/A_1^-					
HA_2/A_2^-					
HA_3/A_3^-					
HA_4/A_4^-					
HA_5/A_5^-					
HA_6/A_6^-					

Questions:

1. Make up another table like the one showing your observations. From your results, fill in each box with an inequality statement about the relative strengths of the two acids (or base) involved; for instance, HIn_1 > NaOH, or HCl > HIn_5.

2. Arrange the thirteen acids in a list, with the strongest at the top and the weakest at the bottom (or, strongest base at the bottom and weakest base at the top).

3. The five indicators used in this experiment, in no particular order, were bromcresol green, orange IV, thymolphthalein, phenolphthalein, and bromthymol blue. Make a list like the following in order to 'give a name to the face' of the unknown indicator solutions:

HIn_1 = __________________
HIn_2 = __________________, etc…for all five of the indicator solutions used.

4. The six unknown solutions (HA_1 etc.) all possess a **whole number** pH value somewhere between 0-14. All have a different value. One of the solutions cannot be narrowed down to one pH value only, but can be narrowed to a range of whole number pH values. Find each solution's pH value(s).

*question 2 cannot be 'set in stone' until question 4 is considered.

Conclusion:

Rank all of the unknown solutions (not including indicators) from most to least acidic.